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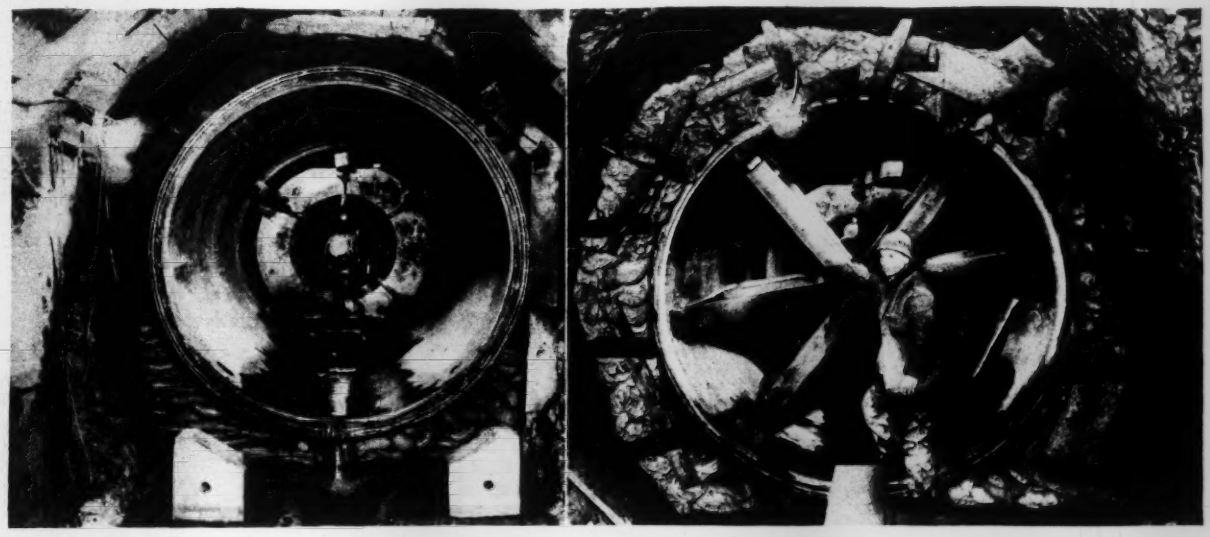


FIG. 1—THE PRESSURE LINE in the tunnel is a special pipe consisting of a reinforced steel shell with a 2-in. shop-spun concrete inner lining and a concrete outer lining placed pneumatically in the field and serving as part of the backing between the pipe and the rock. Views show typical timbered and untimbered sections.

Tunnel Built Under Harbor Entrance for Vancouver Water Supply

Hazards to submerged pipe-line crossing at busy harbor entrance results in construction of 3,100-ft. pressure line at depth of 400 ft. to insure operation of vital link in metropolitan water system

By E. A. Cleveland

Chief Commissioner, Greater Vancouver Water District, Vancouver, B. C.

TO PROVIDE increased capacity and at the same time eliminate the dangers of interruption in the water service to a large metropolitan area, the Greater Vancouver Water District, Vancouver, B. C., has completed a pressure tunnel under the harbor entrance to replace the submerged pipe lines that have been in service for years conveying the supply to the city from the Capilano River across the harbor to the north. Proposed expansion of the supply from this river with corresponding increase in capacity and importance of service made a more permanent type of crossing essential, since the possibility of damage to the pipe lines from shipping was always present and in the past had resulted in partial interruptions. Started in 1931, the tunnel was placed in service in June, 1933, at a cost to the district of about $1,000,000.

At the incorporation of the city of Vancouver, 1886, a company was incorporated for the construction of a water system to bring a supply to the city from the Capilano River. The undertaking was a considerable one for a small community, and its principal difficulty was recognized as the crossing of the Vancouver harbor entrance, known as the First Narrows. A width of about 1,200 ft. at low tide, with a depth at mid-channel of 60 ft. and a tidal velocity reaching 9 m.p.h., made the crossing one of some hazard. The total width of tidal water to be crossed was 2,680 ft. Flexible-jointed cast-iron pipes laid on the bed of the Narrows, although attended at first with some difficulty in the laying operations, were found to meet the situation and have, until completion of the pressure tunnel, been the only means of conveying water across the harbor to the city from the watersheds on the north shore. The methods developed for the laying of these submerged mains were described

at some length in *Engineering News-Record*, Sept. 2, 1926, p. 366.

The water company after two years of operation sold its system to the city, and it was extended as required to provide for municipal growth. In 1926 the supply system was taken over by Greater Vancouver Water District, a public corporation created by an act of the Provincial Legislature for the purpose of supplying water to the lower mainland of the province. The area now embraced by the district is 290 square miles and includes the cities of Vancouver, New Westminster and near-by municipalities (Fig. 1) with an aggregate population of about 325,000.

Hazards to submerged mains

The number of vessels in and out of the Port of Vancouver exceeds that of any other Canadian port, coastwise and deep-sea arrivals last year totaling almost 16,000. All this traffic passes through the First Narrows. It may be realized, therefore, that water mains lying on the bed of the harbor are partly exposed on the foreshore during periods between high and low tide are subject to the hazards of grounding vessels, the dragging of ships' anchors and other similar forms of danger. On several occasions partial interruptions to supply have resulted. The submerged mains, however, remained an economical method for bringing moderate quantities of water across the harbor and have grown in number until there were four 18-in. mains and two 12-in. mains at the First Narrows in 1932 and ten 18-in. mains farther up the harbor at the Second Narrows.

The group of mains at the Second Narrows connects with the district's supply system from Seymour Creek, another stream lying to the north of the harbor from which the major part of the present water supply for Vancouver and immediate neighborhood is drawn. Contemplated rehabilitation and expansion of the Capilano system, which is to be increased to about 45 m.g.d., rendered it imperative that all possible hazards be removed at the harbor crossing. Regulation of streamflow by the future construction of a dam at Capilano Canyon, about 3 miles from the harbor, will provide a regulated supply averaging 200 m.g.d.

Since the formation of the water district the question of a permanently safe crossing at First Narrows (Fig. 2) had been under consideration. A tunnel deep in the underlying solid rock, reached by two vertical shafts to carry water under the gravity head at the present intake on Capilano River, which corresponds in elevation to the future level of the reservoir, was looked upon as the best solution of the problem.

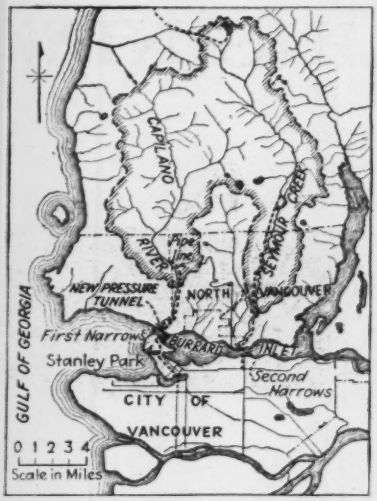


FIG. 2—KEY MAP indicating the relation of the Capilano River catchment area to the tunnel line and the city. The district extends further east and south than shown.

Location and design

The geology of the site is simple. At the Narrows the granite rocks of the so-called coast batholith lie at a depth of more than 1,000 feet. These are overlaid with tertiary sediments consisting of a base course of conglomerates followed by beds or overlapping lenses of sandstones, conglomerates and shales of varying degrees of hardness and texture. At the south shore of the Narrows, which is the northerly shore of Stanley Park in Vancouver, the sandstones are exposed. Here the south shaft of the project could be located without difficulty. The bedrock strata dip to the south at an angle of about 10 deg. and remain uncovered northward to the middle of the Narrows, having been eroded by a westward-moving tongue of the continental ice sheet. From mid-narrows northward they are covered with sand, gravel and boulders up to a depth of about 300 ft., forming the delta of Capilano River.

The tunnel project was made the subject of careful geological studies and extensive exploratory drilling. The particular object of the drill holes was to locate the surface of bedrock beneath the cover of unconsolidated material and to determine the characteristics of the rocks that the shafts and tunnel would penetrate. It was necessary to find a place for a downtake shaft on the north shore of the Narrows, where solid rock would not be lower than about 110 to 120 ft. below high tide and yet be far enough from mid-channel so that its location would not interfere with navigation. This shaft depth was considered as approximately the maximum at which it was safe definitely to program sealing a caisson into the rock surface.

Alternative sites studied

Two sites were eventually found that would give tunnel lengths of 2,000 and 3,100 ft., respectively, and navigation requirements dictated use of the latter. Explorations were also made on a line 6,800 ft. long, which would place the north shaft in solid rock from the surface. The length and maximum depth of 340 ft. from surface in bedrock combined to make the location too costly.

The site selected for the north shaft is between high- and low-water marks, about 800 ft. out from the former. A test boring at this site showed a depth of 110 ft. from high water to sandy shales, which did not produce a core for several feet. The hole was carried to a depth of 402 ft., the elevation tentatively selected as the tunnel level. The south shaft location is in Stanley Park, about 70 ft. back from high-water mark. At this point the sandstones are overlaid with 60 ft. of cemented sands and gravels. The boring showed alternate layers of sandstones, shales and conglomerates to the depth of 400 ft. Final locating of the shafts fixed the tunnel length at 3,104 ft., and its elevation at the north end was established at 400 ft. below sea level. For convenience in construction and to provide a capacity equal to the ultimate flow of 200 m.g.d. from Capilano, the finished diameter of the tunnel was fixed at 7½ ft. and the shafts at 8 ft. A cross-

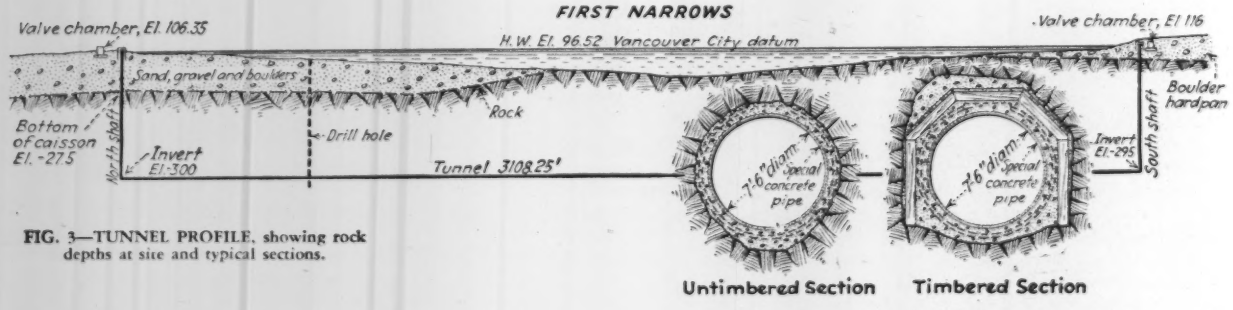


FIG. 3—TUNNEL PROFILE, showing rock depths at site and typical sections.

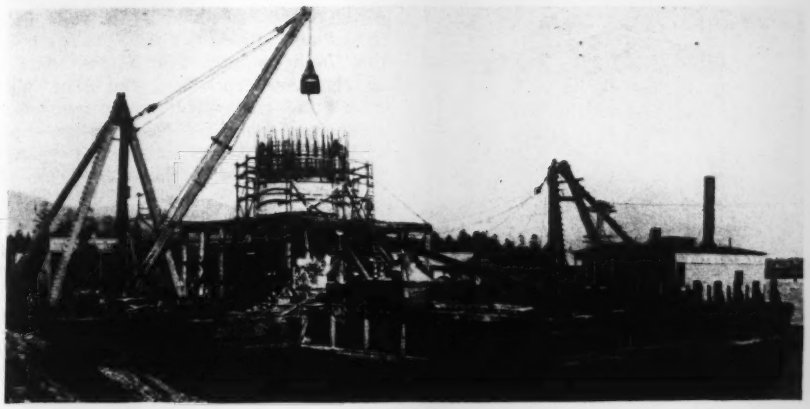


FIG. 4—CAISSON-SINKING operations with dredging under way. The caisson was sunk 130 ft. to rock, sealed, and the shaft continued to the 400-ft. depth.

section along the center line is shown in Fig. 3.

During the early stages of these explorations the advice of the late J. Waldo Smith, consulting engineer to the Board of Water Supply of New York, was sought, and after consideration of the location and the nature of the formation to be penetrated by the tunnel Mr. Smith advised that the tunnel and shafts have a continuous steel inner-lining as a waterstop.

In the weak rock at the site the problem of lining required careful consideration. The unbalanced hydrostatic head in the tunnel to be resisted by the rock cover is 470 ft. For the upper level of the shafts the lining consists of steel shells 8 ft. 8 in. in diameter, 1⅛-in. plate for a depth of 160 ft. in the south shaft, and 1⅛-in. and 1 1/16-in. plate for 110 ft. in the north shaft. These shells transfer to the surrounding concrete envelope, designed as an anchorage, the uplift on the shaft caps resulting from the hydrostatic head. The steel shells are inner-lined with 4 in. of concrete. The remaining lower levels of the shafts are lined similar to the tunnel.

The type of tunnel lining selected consists of a reinforced steel shell with precast concrete inner lining and an outer concrete covering, of the general type used for a number of large water mains in Europe, known as "Bonna Pipe." In this case, however, the inner lining only was precast. The outer concrete covering was placed after setting the shell in the tunnel and became an integral part of the whole backing between the pipe and the rock.

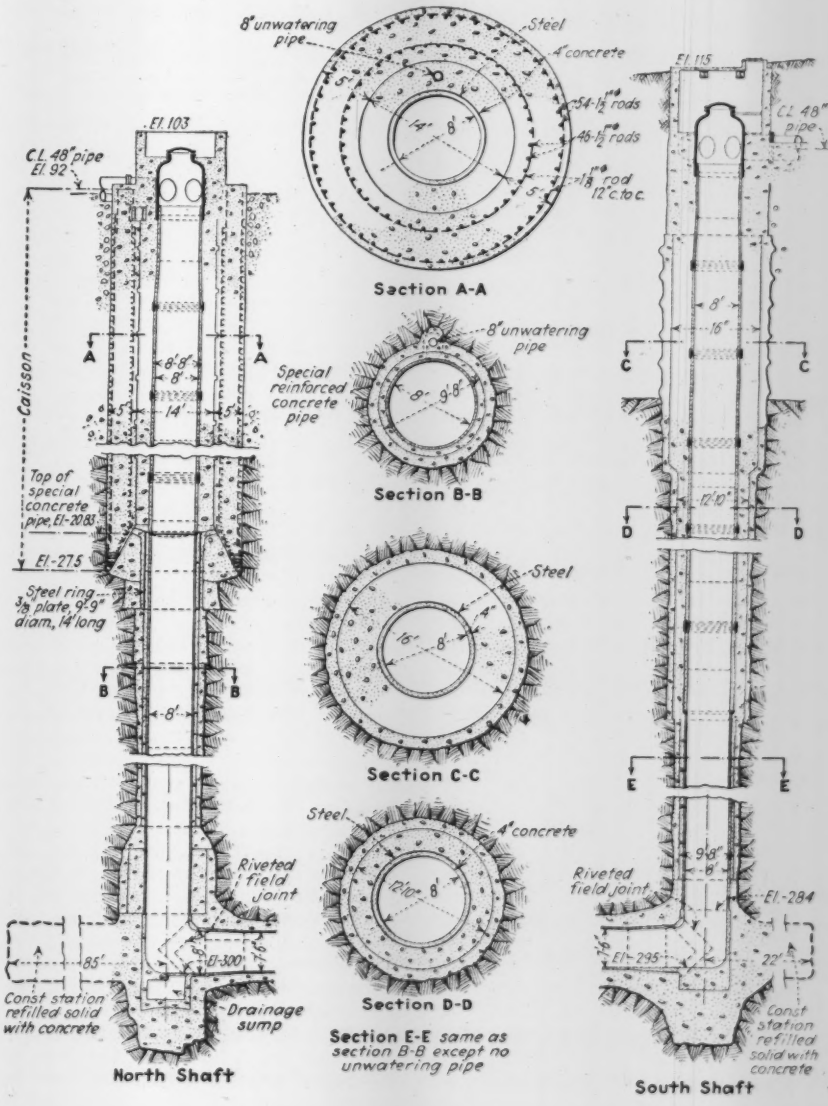
The shafts are topped by cast-steel domes 2½-in. thick, each having four 48-in. flanged outlets for connection to the mains and a 48-in. manhole. The shaft caps were designed and built for a test pressure of 600 lb. per sq.in. and are triple-riveted to the top course of the lining, which is tapered to a 7 ft. 4 in. diameter at the connection.

The construction contract was awarded July, 1931, and on account of the more difficult preliminary work at the north shaft and the slower progress it was decided that the excavation of the tunnel should be largely done from the south shaft heading. The tunnel-lining sections were to be brought in from the north shaft, transported to the south end and the lining proceed northward.

The south shaft excavation was completed November, 1931, the heading turned and tunnel-driving started. The north shaft was not completed until May 10, 1932, at which time the tunnel face was within 55 ft. of the shaft and the connection was made on May 21. By the end of December, 1932, all the reinforced-concrete pipes in the shafts had been placed and more than half of the tunnel lining set. The entire contract was completed within a few days of the contract date, viz., June 1, 1933. The tunnel was placed in commission as part of the water-supply system of the district on June 30.

The south shaft was excavated to a diameter of 18 ft. and timbered through

FIG. 5—SECTIONS through both shafts, indicating the variety of design to meet the changing ground conditions.



about 30 ft. of hardpan. Below this elevation a thin concrete lining was substituted for timbering. The diameter of the shaft inside this concrete lining was maintained at 16 ft. for the next 42 ft. of depth through relatively soft sandstone and shale and then reduced to 12 ft. 10 in. to the bottom of the steel-plate lining. The annular space outside the steel shell of the inner lining provided room for welding the circumferential double butt-strap joints and was subsequently filled with concrete and pressure grouted.

At the north shaft 120 ft. of sand, gravel and boulders and a few feet of the soft rock was to be penetrated before the shaft could be continued in solid rock. The contractor elected to do this by open dredging in a circular concrete caisson having an inner diameter of 14 ft. and walls 5 ft. thick. The sand and gravel at the shaft site were excavated to a depth of about 30 ft. and replaced with pea gravel to reduce skin friction. An additional mound of gravel served to bring the surface above high tide. On this mound the structural-steel shoe was built. A framework of piles and heavy timbers (Fig. 4) formed a working platform. No particular difficulties were encountered, except the usual one of keeping the caisson vertical, until at a depth of about 105 ft. near bedrock a considerable nest of boulders was encountered. Some of these were removed by slings placed by a diver, but others required blasting.

The surface of the bedrock was soft and disintegrated. Sinking was continued for about 17 ft. until the cutting edge reached a foundation in the firmer sandstones at a depth of 130 ft. The use of water jets under a pressure of 165 lb. per sq.in. assisted in the later stages of sinking. On account of the relatively weak rock in which the caisson was seated the excavation was carried 3 or 4 ft. deeper, and a concrete seal about 12 ft. thick was placed by bottom-dump bucket. After the seal had set, the shaft was unwatered and a 6-ft.-diameter shaft was carefully excavated through the seal. This was immediately enlarged to about a 10-ft. diameter. The shell of concrete thus left was underpinned, and a cylinder of $\frac{3}{8}$-in. steel, 9 ft. 8 in. in diameter, 14 ft. long, was placed half above and half below the cutting edge. After careful grouting behind this steel cylinder, shaft sinking was continued in the ordinary way without difficulty. A detailed account of the caisson sinking appeared in *Engineering News-Record*, July 6, 1933, p. 9. Sections of both shafts are shown in Fig. 5.

Tunnel driving

Tunnel excavation was carried on from the bottom of the south shaft without particular incident. For about 1,200 ft. the excavation was in sandstone of varying degrees of texture and hardness. No timbering was required in this section. The larger part of the water encountered in the tunnel came from these sandstone beds as a constant seepage. Farther north highly slickensided shales and one or two beds of conglomerates required timbering. On exposure to air the shales flaked off rather badly. A thin coating of gunite, applied soon after blasting, was found to be very effective in preventing further disintegration. Altogether only 876 ft. of the tunnel required timber support, and of this 600 ft. was in shale.

FIG. 6—READY FOR LOWERING a 14-ft. length of tunnel lining pipe down the shaft. Note the concrete inner lining and the reinforcing steel on the outside wrapped under tension. This steel is embedded in the concrete placed behind the pipe after it is set in position.

As a result of the decision to bring the precast lining pipes down the north shaft and carry on lining operations through that shaft, the inclination of the tunnel necessary for drainage was made to the north, and until the tunnel was holed through the drainage was pumped back to the south shaft. The water was subsequently collected in a sump at the foot of the north shaft, pumped to the surface and measured. The water pumped from the tunnel did not exceed 60 g.p.m. and after completion of the excavation averaged less than 50 g.p.m.

The alignment of the tunnel was carried northerly for 3,010 ft. from piano-wire plumb lines suspended 9 ft. apart in the south shaft and met the line carried down from the north shaft at a distance of 55 ft. from that shaft with an error of less than 0.1 ft. The levels were almost exact.

After driving was completed, the next step was to clean up the floor of the tunnel and lay a concrete invert in which were embedded 24-lb. rails (set to line and grade) for transportation of the lining pipes. The friable nature of the sandstones and the ease with which the shales and water again became mud indicated that the handling and setting of the lining pipes could be performed with the least difficulty by this method.

Lining

The sections of lining pipe consist of steel cylinders wound with two or three courses of reinforcing steel on the outside and a spun concrete lining. No exterior concrete was placed on the pipes at the plant, and as a result each pipe was 5 to 6 tons lighter than it otherwise would have been. The shaft sections were 12 ft. long and the tunnel pipes 14 ft.

The manufacturing operations were in sequence from end to end of the shop. The $\frac{5}{16}$-in. steel plates were sheared, formed into half cylinders, welded into cylinders and the ends rolled inward to provide 1-in. flanges for welding together in the tunnel. Inside the shells were placed $\frac{7}{8}$-in. spiral and longitudinal reinforcing rods. On the outside of the shell were wound, under tension, two or three courses of $\frac{5}{8}$-in. round steel rods separated by $\frac{3}{8}$-in. steel rods placed 8 in. apart longitudinally. About one-half the tunnel pipes were built with two courses of exterior reinforcing, and the remainder had three courses. With the former type the stresses in the steel, computed for a bursting pressure of 260 lb. per sq.in., were about 24,000 lb. per sq.in. On account of the unbroken nature of the sandstones and the resulting support, the high stresses in the steel were considered justifiable for this part of the tunnel. In the softer, more broken and more elastic shales enough reinforcing steel was added to the cylinder to reduce the stresses to about 14,000 lb. per sq.in. for an unbalanced internal pressure of 300 lb. In each length of pipe 2-in.-diameter grout pipes were placed to provide a 7-ft. spacing in the tunnel on the midline of the roof.

The 2-in. concrete inner lining of the cylinders was centrifugally placed. Concrete with coarse aggregate not exceeding $\frac{1}{4}$ in. was fed from a trough moving longitudinally in the pipe, which was turned on spinning rolls at a peripheral speed of 2,400 ft. per minute for the 7-ft. 10-in. tunnel pipe and 2,700 ft. per minute for the 8-ft. 8-in. shaft cylinders. This inner lining acquired a smooth surface and the concrete had a weight of 155 to 160 lb. per cubic foot. After curing for fourteen days in a water spray, the pipes were ready to be moved by barge to the site of the work. Manufacturing of the pipe was done by the Pressure Pipe Co. of Canada at a new plant in North Vancouver.

At the foot of the north shaft a station was excavated at tunnel level

extending the tunnel 85 ft. back of the shaft, providing space for double track and crossover, storage for cars, pneumatic gun and other equipment. Pipe sections were lowered end-on down the shaft (Fig. 6) and turned by a small tugger hoist and suitable slings to a horizontal position. At the station they were received on a specially designed car with a cantilever arm sufficiently long to reach mid-length of a tunnel pipe and provided with a pivoted plate curved to pipe radius at the end.

A 35-hp. storage-battery locomotive, used for all the underground haulage, pushed the pipe car to the required location in the tunnel. Easy and sensitive vertical and horizontal adjusting devices on the car allowed the pipe to be set on concrete blocks on the invert of the tunnel and brought to proper grade and alignment. After setting the first pipe, each successive pipe was set with its flange tightly abutting that of the preceding pipe and wedged to the rock in its final position. A sandbag bulkhead was placed to cover the peripheral opening between the pipe and the rock walls of the tunnel (Fig. 1).

Concrete with ¼-in. maximum size aggregate was placed pneumatically first at the bottom and then over the top of the pipe where sufficient room was available for workmen to rod the material carefully. In the good rock sections of the tunnel great care was exercised in the removal of drummy rock and in cleaning the walls and roof. In those sections where the heavier type of pipe was used the timbering was not withdrawn.

Electric welding of the joints was done, for the most part, after concreting but before water pressure built up in the surrounding rock. A narrow band of reinforcing mesh was then placed circumferentially in each joint space. These were carefully filled with cement mortar troweled and finished to a smooth surface, making a continuous waterway of excellent hydraulic characteristics. Grouting under pressure of about 90 lb. followed, where required, by high-pressure grouting at 180-lb. pressure, completely shutting off the water from the outside.

Valve chambers

About 32 ft. away from the shaft cap in Stanley Park and 65 ft. away from the north shaft are the valve chambers. The former is set in an excavation in the cemented gravels or hardpan with its surface elevation about 2 ft. below the general level of the park at that place. The latter is set on a pile foundation in a shallow excavation in the foreshore with its top 6.5 ft. above extreme high tide and surrounded with an earthfill protected with a granite revetment inclosing the shaft cap.

Connection between the shaft caps and valve chambers is made by 48-in. cast-steel bends (Fig. 7) and by straight runs of ¾-in. welded steel pipes incased in concrete. Three of the pipes in each valve chamber are for the present closed with blank flanges, and the remaining pipe is provided with a specially designed 48-in. double-disk cast-steel gate valve tested to 425 lb. These pipes in turn connect with a 60-in. supply main on the north shore and on the south to the 70-in. main running to the city.

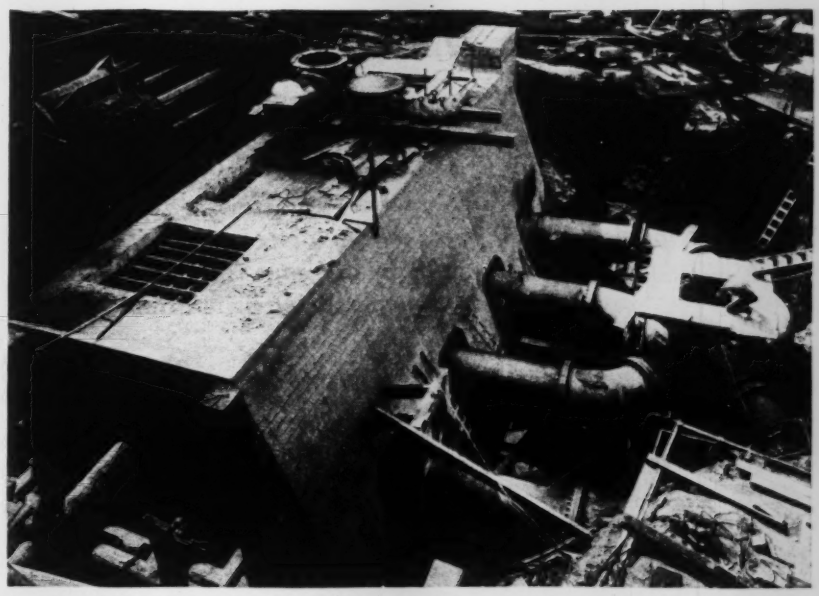


FIG. 7—SHAFT CAP, valve chamber and 48-in. connecting pipes.

On completion of the valve chambers and connecting pipes the tunnel was filled with water, heavily chlorinated, and subjected to a continued pressure test for watertightness at 210 lb. per sq.in. Leakage from valve chamber to valve chamber proved to be slightly under 250-gal. per 24 hours. After the pressure test, water was flushed from the tunnel, and refilling continued until the bacteriological tests were satisfactory. The tunnel was immediately put into service.

The north shaft is covered by a small access house. As the site is about 800 ft. out from the high-tide line, a small water-wheel-driven generator set provides a band of light around its upper section and lights the stone embankment extending to the shore.

Organization

The project was carried out by the Greater Vancouver Water District under the general direction of the writer, with W. H. Powell, engineer of the water district, in direct charge. Fred C. Stewart was resident engineer. Sanborn & Bogert, consulting engineers, New York, were associated with the late J. Waldo Smith, consulting engineer.

The general contract was held by the Northern Construction Co. and J. W. Stewart Ltd., Vancouver. N. D. Lambert was general superintendent, and William Smaill chief engineer. H. E. Carleton was tunnel superintendent and R. M. Wynne-Edwards was in charge of caisson work.

Shanghai as Market for U.S. Building Materials

A market for Western building materials is developing in Shanghai, according to recent reports made public by the U. S. Dept. of Commerce. Although 80 per cent of Shanghai's buildings are native-style structures, characterized by simplicity of construction detail, modern building is making great strides in the city. Certain sections of the international settlement and of the French concession have now a thoroughly European atmosphere. In these foreign controlled areas large foreign firms have offices and modern buildings. There are also several large and luxurious hotels, as well as many apartment houses for the use of foreigners and the wealthy Chinese classes.

Most of the recent construction in Shanghai has been in American style, with the exception that economy is generally taken more into consideration in local projects. American supplies are also being used to a certain extent in the construction of Chinese houses. There is a market in Shanghai, the report states, for the following products: sheathing and building papers, roll roofing, asphalt shingles and plastic roofing and cements. The market for sheathing and building papers is chiefly for asphalt-saturated felt and roofing felts.

Pertinent Considerations in Municipal Power Planning

Elements of cost, legal questions and requirements for flexibility and dependability that must not be overlooked by a community when contemplating a change from privately operated to municipally operated electric utilities

By Arthur Wardel Consoer
Consoer, Older and Quinlan, Consulting Engineers, Chicago, Ill.

SCORES of small towns and many cities served with electric light and power by large public utility companies have become restive under present rates and are considering switching over to municipal ownership in the hope of obtaining lower rates. The Public Works Administration openly favors such a step. As a consequence, many city engineers have found themselves, or may very soon find themselves, faced with the requirement of determining the feasibility of building a municipal power plant or of passing upon a report prepared by outside consultants. For the advice of such city engineers or of engineers not in city service who may be asked for an opinion upon the subject of municipal ownership the following article has been prepared. In brief form it outlines the principal requirements to be met and some of the pitfalls to be avoided.
—EDITOR.

IN RECENT MONTHS one of the interesting developments in the period of deflation has been the increasing interest in the planning and construction of municipal light and power plants. Most of these projects have been urged for proposed competition with existing privately owned utility companies. Some few of them have been designed to furnish light and power in localities without such facilities, such as summer-resort developments and isolated villages.

The principal argument advanced in favor of municipally owned and operated light and power plants has been the claim that utility companies cannot reduce their rates because they are loaded down with unnecessary overhead expense, and that the valuations used for rate-making purposes are excessive for present-day costs. It is also pointed out that with far-flung utiltiy empires, the cost of generation, transmission and distribution is often more costly than is the case with a small compact municipal installation.

Many cities and villages throughout the United States are now considering the advisability of building their own plants, particularly in cases where franchises for street lighting and power for water pumping have expired or are about to expire. Under such circumstances, discussion as to the relative merits and disadvantages of private and publicly owned power and light utilities waxes warm and furious. In such cases the consulting engineer or the city engineer, where he is qualified on the subject matter, has an important rôle to play. The former certainly should not yield to the temptation to obtain a large fee, where the construction of a municipal light and power plant cannot be economically justified. Where rate adjustment is possible, new construction should not be advocated to replace existing facilities until the possibilities of rate adjustment have been plumbed and determined by careful investigation, accurate reporting and skillful negotiation.

The feasibility of a local light and power plant is usually determined through examination by public officials of a report by consulting engineers, although in many cases the reports are not paid for but are prepared gratuitously by engineers in the employ of machinery manufacturers. Whether the latter method is good public policy is open to serious doubt, regardless of the reputation of the manufacturer and regardless of the skill and integrity of his sales engineers. A report by consulting or practicing engineers on a municipal plant can also be subjected to unfavorable criticism, if the authors are actuated by any motive other than a determination to give the municipality complete and unbiased information.

Such reports, by whomever prepared, should follow certain self-evident principles of investigation and technical reporting.

Character of load

The character, distribution and amount of the load that can be reasonably anticipated for a municipal plant should be carefully determined. The details of this load should be accurately stated in the report to justify the conclusions reached regarding peak loads and total kilowatts consumed per year during the life of the bond issue for construction. This will involve detailed investigation of light and power bills in the municipality for at least ten years past and a conservative forecast of future population growth and of increased demands for light and power at least during the life of the bonds to be issued. In this connection, attention should be given to the apparent slowing up at present of the growth of villages and cities and the trend of population from urban to rural areas.

Where industries are using considerable blocks of power in a municipality considering the installation of a local plant, investigation of the industries must be made as to the possibility of getting their patronage for a municipal plant. Likewise large commercial users must be interviewed before an assumption is made that their patronage is assured. Among the domestic users the results of a referendum will give a good indication of what proportion of the residential use could be expected to use the new plant.

Effect of competition

In most cases where a municipal plant is under consideration, a competitor is already in the field. This competitor will influence the amount and character of load obtainable at the outset and will influence the rapidity of increase in business. This competition affects the operating income from the very start, and due consideration must be given to it in the design of the municipal plant and in the predictions of financial results to be obtained. The writer recently reviewed a report on a municipal light and power plant in which the authors of the report assumed that the utility company could be ordered out of business as soon as the municipal plant was ready to function, on the theory that the company's franchise to use streets and alleys had expired. That may be "good law" in some localities, but the writer's experience with municipal water plants in competition with private water companies and experience with street-car operation where franchises have expired makes one a bit skeptical about the soundness of such an interpretation of the law. At any rate, reliable legal opinion should be obtained to justify any such assumptions.

The probability of rate reductions on the part of the privately owned utility should not be overlooked. Also, the influence of local stockholders and bondholders interested in maintaining the soundness of their investments in the privately owned utility should be considered. In several Illinois cities where municipal ownership of light and power plants was rejected at popular elections in recent months the unfavorable vote was ascribed to the influence of such stock and bondholders.

Reliability of service

The plant and distribution system should be designed so that it will give as reliable service as that furnished by the existing utility. Consideration should be given both to a steam plant and an oil-engine plant, and occasionally to a hydroelectric plant or a combination of these. Continuous service for

all consumers must be provided. Sufficient equipment for maintaining practically constant voltage at customers' premises during periods of peak load must be included in the design. Ample generating capacity must be held in reserve at all times, both to provide for failure of operating units and to allow for the withdrawal of units from service for periodic inspection and repairs. In addition to the requisite of reliability, flexibility of design is needed to provide for substitution of more efficient equipment in the future. In the financial set-up for the project it is important that provision be made for installation of additional equipment, as it will be required for future development during the life of the bonds to be issued for the project. The site of the plant should be selected and the buildings designed to provide ample room for development during the life of the bonds and thereafter. Consideration in selecting a site must be given to a source of available water supply, facilites for economically receiving and unloading fuel and proximity to the load center. Usually a compromise has to be made between these practical factors and such other matters as zoning restrictions and cost of property.

Construction costs

The estimate of cost of construction should be detailed and reliable, and should include an accurate estimate of labor costs for installation, as well as all necessary incidentals and auxiliaries, such as fuel-oil tanks, railroad sidings, customers' service and meter facilities, devices for correction of power factor and voltage where economically feasible, facilities for disposal of ashes and smoke and fly-ash eliminators in steam plants, etc.

Provision should also be made in connection with setting up figures for first cost or capitalization and for load-development cost, for such important factors as operating capital, stock of meters, wire, fuel, transformers, station supplies, etc., interest during construction, discount on bonds, legal and engineering expenses, insurance and an allowance for contingencies. The costs of installing equipment are apt to be surprisingly high as viewed by municipal officials, and can only be accurately estimated when studied in the light of experience and types of equipment involved.

Distribution costs

Where an existing utility system is being operated, the installation of a distribution system for a competing municipal system will be complicated and will be increased in cost by reason of interference from existing poles and wires.

Detailed cost estimates of the distribution system and accurate estimates of the probable sale of current are particularly needed because distribution costs vary considerably in various localities. A recent study of such costs for five different situations showed variations in distribution cost from 2.7c. per kw.-hr. to 9.2c. These variations are due principally to variations in customer density, variations in average use and in the proportion of underground and overhead construction. The costs of generating and transmitting electrical energy vary enough also to make imperative accurate estimates in any report on a municipal light and power plant.

Load characteristics

The report should include a study of the load factor to be expected in the operation of the municipal plant. This must be done if equipment is to be selected intelligently. The purchase of equipment with unusually high efficiency and quality is justified economically only where a high load factor can be safely predicted. In such cases the increase in fixed charges is balanced or exceeded by savings in operating expense because of the more nearly continuous operation of the high-cost equipment at high efficiency. The accurate determination of the load factor will permit a prediction of the plant's suitability for carrying peak loads for a considerable length of time without sacrificing efficiencies during these high-load periods.

Operating costs

Fixed charges and operating expenses must be accurately and conservatively estimated in the financial set-up. The item of depreciation should be fairly considered and not merely roughed off. Interest charges, amortization charges and ordinary repairs and maintenance should be listed separately in the report, so that they can be reviewed and checked. In estimating the cost of fuel and lubricating oil, coal or other fuel, too much weight should not be given to present low prices. The amount of fuel to be used will vary, depending on how the load is taken on, and data from plants operating with similar load factors and other conditions should be used in estimating fuel requirements. The report should explain in detail the personnel anticipated for operating labor, superintendence, clerical assistance, etc., with wage scales, in order that these factors may be reviewed by the interested municipal officials. It cannot reasonably be assumed that present-day wage scales can be maintained for the next 20 to 30 years. Any sound estimate of operating expenses should include an allowance for bad accounts receivable, which are inevitable in any going business.

In predicting earnings of a proposed municipal light and power plant, attention should always be called to the item of taxes. In estimating the value of operating a municipal plant an allowance should be made for taxes which will be lost by displacing or reducing in value the taxable property of the competing privately owned utility.

Related services

Often consideration should be given to combining an existing water-pumping station with a new light and power plant, with a view to introducing operating economies. However, such a study must be carefully made. In one case that was recently studied by the writer, combined operation, which at first thought seemed advantageous, was later found to be objectionable because combined operation of a deep-well pumping station and a power plant necessitated locating the steam-generating station a considerable distance away from the center of the electrical-distribution system and from a condensing water supply.

Legal questions

Engineering reports should always be accompanied by expert opinion as to the legality of the proposed construction and method of financing. There are cases where municiptlities have been enjoined from operating plants after they have been constructed.

Some attention must be given in present and future reports to probable changes in the price index. Inflation with accompanying increases in valuation of existing utilities will render it more difficult to justify the construction of local plants and will make it more difficult to obtain rate reductions.

Because the construction of a municipal power plant involves a considerable expenditure of public funds and because it involves the possible reduction in the value of investments in existing utilities, and also because there are locations where such a plant cannot be economically justified, preliminary reports on such projects sho ld be unusually complete and accurate. Adequate appropriations for the engineering services involved for such reports are desirable from the standpoint of public policy, and any attempt to prepare such a report contingent upon such a project being consummated should not be encouraged by municipal officials.

Reliability and quality of service for light and power are fully as necessary as lower rates for the average customer, and no village board or city council should be stampeded into a decision to build a local plant based on a report that has been hastily and cheaply prepared. Where cities have received an engineering report based on thorough investigation and containi.g accurate estimates of construction costs, operating costs, fixed charges, repairs, maintenance and probable revenue, they should not hesitate to undertake the installation of such a plant if the existing utility is unwilling or unable to offer rate conditions as good as, or better than, those promised by the engineering report.

Experiences in Operating a Blower Driven by Sludge Gas

Comparative results of two nine-month periods indicate that Springfield Sanitary District has reduced by more than half its cost of power purchased to run air compressors

By W. B. Walraven
Engineer, Springfield Sanitary District, Springfield, Ill.

ABOUT a year ago, at the sewage-treatment plant at Springfield, Ill., there was installed a gas engine to burn the gas generated in the sludge-digestion tanks and to drive one of the two blowers supplying compressed air to the aeration tanks. Before that time both blowers had been driven by electric motors, and the sludge gas had been burned under a hot-water boiler to supply hot water for heating the digestion-tank contents. According to the new method of operation, one blower is still driven by an electric motor. Heat for the digestion tanks is provided by using the cooling water from the jacket of the sludge-gas engine. The new installation was described in detail in *Engineering-News Record*, May 25, 1933, p. 682. In the following article Mr. Walraven recounts some of the observations made during nine months of operation. —EDITOR.

SINCE the installation at Springfield, Ill., of a gas engine using sludge gas for fuel to drive a blower at the activated-sludge plant, many inquiries have been received relative to the results obtained. Most of these inquiries naturally center around the net savings resulting from this method of operation, although some letters still ask whether or not the unit will run successfully on sludge gas. So far as the Springfield situation is concerned, it can be stated that the engine has been running for more than nine months, practically continuously, except when the gas supply fails, and that all indications are that the investment will have been paid back before all the newness has been worn off the units.

No way appears feasible to set down figures to show definitely the amount of money the gas engine has saved the sanitary district, because an accurate comparison is not available with conditions as they would have been in case the gas engine had not been installed. Moreover, no new installation can be proved absolutely worth while until it has completely paid for itself out of its earnings. However, the accompanying table gives at least one measure of the results obtained, the fairly steady reduction in the amount of electric power consumed in supplying compressed air to the aeration tanks.

During October, the best month so far experienced, the gas-engine-driven blower compressed more than 72 per cent of the air required, and during the first two weeks of November more than 90 per cent of the plant load was developed by the engine. However, it is not to be expected that this condition will continue for an indefinite period.

In the *Engineering News-Record* article referred to above, it was stated that the construction cost chargeable directly against the gas engine was $7,475. If the life expectancy of the units were known, figures to represent annual savings could safely be given, but it is not possible to go farther than to say that if the units continue to perform during the next four months as they have in the past nine, the engine and heat-salvage units will have paid their way completely. The writer is willing to state, however, that had he known as much about operating the units last spring as he has subsequently learned, the savings would be considerably greater.

In connection with observations upon the gas engine some rather interesting experiences with the digestion tanks have been encountered. Formerly they were heated by means of a gas-fired boiler, but they are now heated by the waste engine heat. During the past three months the temperature of the sludge within the tanks has been permitted to rise to above 100 deg. F. and even as high as 108 deg. Sufficient data are not available upon which to base positive conclusions, but the writer is beginning to wonder whether 80 deg. F. is the optimum temperature, as has ordinarily been considered. It can be said definitely that these tanks have behaved well at 100 deg., and that the supply of gas has been both steady and high in quality. Following a rain, with the consequent increase in fresh sludge volume, the production of gas rises quickly, with a subsequent rather rapid drop back to normal. So far the sludge has dried well on the sand beds, cracking into small particles, without any increase in odor nuisance. A period of three months is not sufficiently long, however, to make any sweeping statements about the effect of increased temperature, particularly when no "control" tank for comparison of results exists.

It has been interesting to note that higher temperatures are now maintained in the four tanks with waste heat than were formerly maintained in two tanks when the gas was burned under a boiler. The most important factor in this procedure has been the increase in heating-coil surface inside the tanks, necessitated by the attempt to salvage the engine heat. In this connection, two heat-transfer problems arise, first to absorb the heat at the engine, and second to get rid of it at the tanks.

Tests made prior to the installation of the gas engine disclosed some enlightening facts concerning the transfer of heat into sewage sludge. Using galvanized, wrought-iron heating coils, a coefficient of heat transfer was found as low as 10.2 B.t.u. per hour per 1 deg. difference in temperature per square foot of heating surface, with the coils surrounded by sludge which averaged 12 per cent solids. With other coils surrounded by thin sludge, approaching supernatant liquor in density, the coefficient was found to be about 39. Since these tests were conducted within tanks having more than 400 sq.ft. of heating surface, the results should be quite indicative.

A great deal remains to be known about the use of sewage-sludge gas for power, and whether or not it will be more widely used depends a great deal upon the care with which individual units are chosen for the next few installations. There is no beaten path to follow except that laid down by the fundamental concepts of mechanical engineering. The quality and quantity of the gas are variable from time to time; there may be excessive amounts of hydrogen sulphide present; the pressure at which the gas is generated may be too low; or worst of all, the engine may not be large enough for the power unit which it drives. These are some of the things that may wreck an otherwise well-planned development. But the experience at Springfield leads the writer to believe that so long as there are heat units in sludge gas, they may economically be put to work.

MONTHLY POWER CONSUMPTION FOR FURNISHING COMPRESSED AIR TO AERATION TANKS OF THE SPRINGFIELD SANITARY DISTRICT

	For Nine Months in 1932 (Motors Only in Use)			For Nine Months in 1933 (Gas Engine and Motors in Operation)		
Month	Sewage Through Aerators, m.g.d. Aver.	Cu. Ft. Air Per Gal. of Sewage	Kw.-Hr. to Blowers for Compressing Air	Sewage Through Aerators, m.g.d. Aver.	Cu. Ft. Air Per Gal. of Sewage	Kw.-Hr. to Blowers for Compressing Air
February	10.2	0.63	93,620	9.2	0.71	52,040
March	8.5	0.63	108,410	7.5	0.89	57,910
April	7.7	0.83	96,050	9.5	0.71	66,300
May	7.5	0.89	100,080	6.4	0.64	36,160
June	9.6	0.82	117,220	8.8	0.73	58,170
July	6.6	0.99	111,260	5.7	1.10	41,030
August	7.7	0.83	99,820	5.1	1.02	47,970
September	5.6	1.20	99,860	5.5	0.98	28,320
October	5.3	1.22	96,470	5.6	0.98	21,830
Average	7.63	0.89	102,530	7.03	0.86	45,525

Welded Lift Bridge Built in Japan

With trusses of Vierendeel type, a span of 69 ft. and a special operating mechanism with counterweights in the tower legs and lifting machinery within one abutment, the structure is unique in design and appearance

By Shinichi Komuro

Chief Engineer, Yokogawa Bridge Works, Ltd., Tokyo, Japan

AN ALL-WELDED vertical-lift bridge, spanning between coal-unloading piers at the South Manchuria Railway Co.'s freight wharf at Kawasaki Harbor, has recently been completed. The lift-span trusses are of the Vierendeel type, and all four of the counterweights are confined within the columns of the 40-ft.-high towers. The lifting arrangement, patented by Taneyoshi Sakamoto, a government railway engineer, is of the compensated-cable type, enabling all of the lifting machinery to be installed within the shore abutment below the surface of the roadway. Absence of lifting machinery on the span improved the appearance and also lowered the cost.

Design details

The span of the trusses is 69 ft., and they are spaced 12 ft. c. to c., providing a 10 ft. 10 in. roadway. The maximum lift of the span is about 30 ft. The bridge is designed for a uniform live load of 102 lb. per sq.ft. plus a live-load impact of 33 per cent. A wind load of 30 lb. per sq.ft. and the effect of earthquakes were also considered in the design. The trusses are 8 ft. 2 in. deep at the center of the span and 6 ft. 6¾ in. at the ends. The section of chords and vertical members is made up of three plates forming an I-section. Flange plates are 9⅞x15/32 in., and web plates are 10⅞ x 15/32 in.

The flanges are welded to the web on both sides by intermittent fillet welds ⅜ in. long, spaced about 4 in. apart. Near the panel points the welds are made continuous. In welding the trusses and towers the members were assembled with forms and clamps and tack-welded at suitable points. Final welding was then done symmetrically in order to reduce shrinkage stresses to a minimum.

There is a total of 4,264 ft. of welding on the bridge, while the weight of the structural steel is about 30 metric tons. There are also 15 metric tons of cast iron and scrap steel in the counterweights. All welding was done in the shop, and the lift span and the two towers, each as a single piece, were transported on barges from the fabricating plant to the bridge site.

The final test made on the operation of the lift span, equipped with one 7½-hp. electric motor, showed the following results:

	Time Required, Sec.	Current Required, Amp.
Span going up	52	16.5
Span going down	49	14.5

Contractors and engineers

This project was carried out under a special contract signed in November, 1932, betwen Kazuzo Ichikawa, chief of the Kawasaki construction department, Southern Manchuria Railway Co., and Teiji Ebashi, managing director, the Yokogawa Bridge Works, Ltd. The general plans of the bridge were prepared in the office of the railway company under the direction of Kenkichi Koyanagi, and the detailed plans of the bridge and the lifting machinery were prepared by the fabricator, the Yokogawa Bridge Works, with the writer in charge of the work. Tsurukichi Tsuruoka, of the Southern Manchuria Railway Co., was the engineer in charge of construction. The bridge was completed in April, 1933.

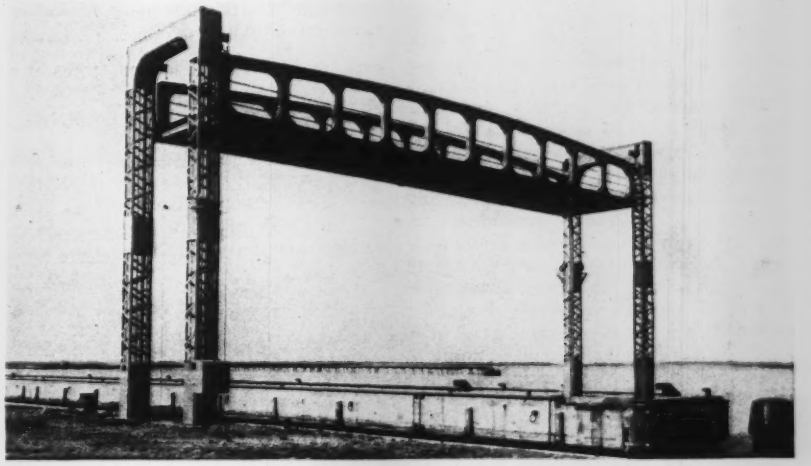
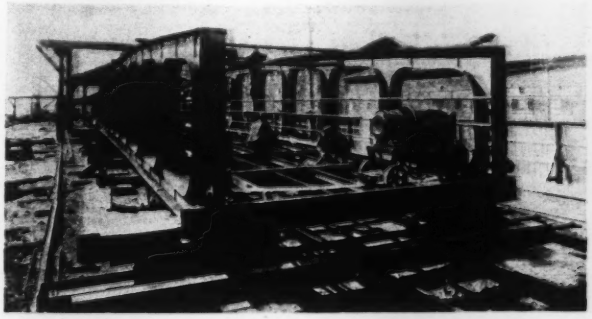


FIG. 1—WELDED LIFT BRIDGE in Japan with a span of 69 ft. designed for a live load of 102 lb. per sq.ft. on a 10-ft. roadway. The counterweights are confined within the tower legs. Operation is by means of a compensated-cable system with operating machinery below and behind the land abutment.



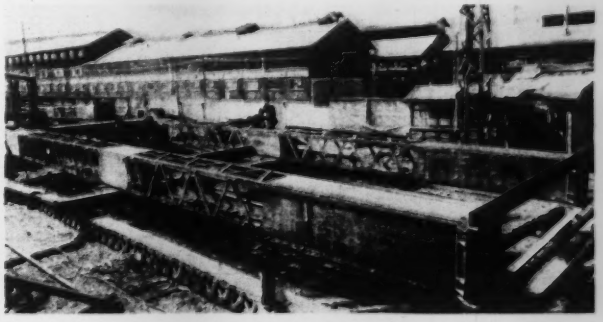


FIG. 2—TOWERS AND LIFT SPAN were welded complete in the shop and transported to the bridge site on barges.

Discharge Coefficients for Tainter Gates

Theoretical expression for discharge coefficient of "ideal sluice-gate" used as a base for determining coefficient for tainter gate, and the coefficients so computed agree with those determined experimentally

By Robert E. Horton
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A TAINTER GATE with round-ended piers and a horizontal floor extending downstream at a level with the sill constitutes an ideal sluice-gate, which may be defined as an orifice with contraction suppressed at bottom and ends but with full contraction at the top and with the side walls and bottom of the channel of approach extended downstream so as to support the jet and prevent it expanding beyond the limits of the opening.

Following somewhat the lines of Boussinesq's analytical treatment of weirs[1]—i.e., by balancing the forces acting on the water approaching the opening—Koch and Carstanjen have developed an expression for the discharge coefficient for an ideal sluice-gate with the lip of the gate inclined at an angle Θ to the horizontal[2]. This expression can be used as a base for determining the discharge coefficient of a tainter gate.

Referring to the chart and using feet and seconds as units, R = the radius of the gate; p = the height of the pivot above the floor; w = height gate is raised; Θ = angle of lip of gate to horizontal, in radians; D = depth of water upstream from the gate piers, H_c=depth to center of gate opening; N = depth ratio $= \frac{D}{w}$; $H_c = D - \frac{w}{2}$; $\cos\Theta = \frac{p - w}{R}$; c_1 = theoretical coefficient of discharge; C = actual discharge coefficient; and $f = \frac{C}{c_1}$.

The result of Koch and Carstanjen's analysis is the implicit equation for c_1,

$$c_1 = \frac{\left[\Theta - \frac{1-\cos\Theta}{\sin\Theta}\cdot\frac{1}{N}\right]\left(2-\frac{1}{N}\right)}{\left(2-\frac{c_1}{N}\right)\left\{1+\Theta-\cos\Theta-\frac{1}{N}\left[\frac{1-\cos\Theta}{\sin\Theta}+\frac{1}{2}\left(\frac{\Theta}{\sin\Theta}-\cos\Theta\right)\right]\right\}} \quad (1)$$

As N approaches infinity,

$$c_1 \text{ approaches } \frac{\Theta}{1+\Theta-\cos\Theta} \quad (2)$$

Let z = the right-hand member except the function

$$\left(2-\frac{c_1}{N}\right)$$

Then

$$c_1(2N - c_1) = Nz \quad (3)$$

Solving this quadratic gives

$$c_1 = N \pm \sqrt{N^2 - Nz} = N\left(1-\sqrt{1-\frac{z}{N}}\right) \quad (4)$$

Obviously only the negative root of the radical can have a real value.

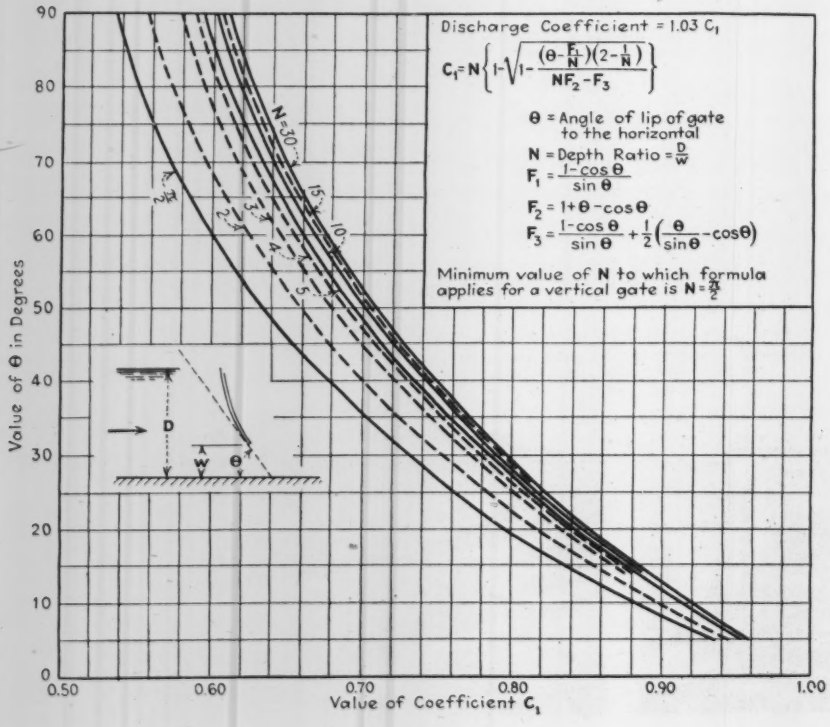
$$\text{Let } F_1 = \frac{1-\cos\Theta}{\sin\Theta}. \quad (5)$$

$$F_2 = 1+\Theta-\cos\Theta. \quad (6)$$

$$F_3 = \frac{1-\cos\Theta}{\sin\Theta} + \frac{1}{2}\left(\frac{\Theta}{\sin\Theta}-\cos\Theta\right). \quad (7)$$

All of these expressions are functions of Θ alone, and their values can readily be calculated.

DIAGRAM FOR DETERMINATION of the analytic coefficient for tainter gates.



Substituting these functions in (4) gives for Eq. (8) $c_1 =$

$$N\left\{1-\sqrt{1-\left[\frac{\Theta-\frac{F_1}{N}\left(2-\frac{1}{N}\right)}{NF_2-F_3}\right]}\right\}.$$

The last equation is a general analytical expression for the discharge coefficient for an ideal sluice-gate either vertical or inclined at an angle to the horizontal from zero to 180°. From the conditions of its derivation its application is limited to cases where N is not materially $< \frac{\pi}{2}$. For $N = \frac{D}{w} = \frac{\pi}{2}$, $H_c = D - \frac{w}{2} = w\left(\frac{\pi-1}{2}\right) = 1.0708\,w$.

Eq. (8) applies, therefore, to all cases where the orifice head exceeds 107 per cent of the vertical width of the gate opening. With this limitation, Eq. (8) applies not only to cases where the gate itself is inclined, such as a tainter gate, but to cases where the gate is vertical but has a beveled lip, provided the out-

flowing jet is in contact with the bevel. For a beveled gate the angle of bevel to the horizontal is to be taken as the value of Θ.

The formula is, however, analytical and requires experimental data to determine the value of $f = \frac{C}{c_1}$.

An extensive series of experiments was conducted by the author and others at the hydraulic laboratory of Iowa University on a sluice-gate 10 ft. in length with various widths of opening, with contraction fully suppressed on the bottom and sides and complete at the top and with the jet fully supported downstream at the sides and supported at the bottom by an apron with a slope of $\frac{3}{8}$ in. per ft. There was a vertical center post mid-length of the opening, $6\frac{1}{4}$ in. wide, with rounded upstream corners, which produced no appreciable contraction. The water was measured by an accurately calibrated suppressed weir. The experiments will be fully described in a pamphlet, publication of which is pending.[3]

The sluice-gate was a full-sized model of a gate formerly used to supply water to two large overshot water wheels in the Gallego Mills at Richmond, Va.

Column 6 of Table I gives the observed coefficients computed by the formula applicable to orifices

$$C = \frac{Q}{wL\sqrt{2gh}}, \qquad (9)$$

where Q is the measured discharge, in sec.-ft., and L the horizontal length of opening. This includes vertical gates and gates with various angles of bevel, as shown in column 1.

Column 7 shows the ratio of the observed coefficient to the theoretical coefficient calculated by Eq. (8). This gives as an average value, $f = 1.0307$ or $C = 1.03\ c_1$. Applying this coefficient to Eq. (8) gives the following formula for determining the coefficient of discharge applicable to a tainter gate or other vertical or inclined orifice conforming to the conditions of an ideal sluice-gate:

$$C = 1.03\ N\left\{1 - \sqrt{1 - \left[\frac{\Theta - \frac{F_1}{N}\left(2 - \frac{1}{N}\right)}{NF_2 - F_3}\right]}\right\} \qquad (10)$$

Thereon M. Ripley has recently published experimental coefficients for a tainter gate of 20-ft. radius and a length of 26.67 ft. (*Civil Engineering*, July, 1933, pp. 386-388.) Contraction was suppressed on three sides, and the jet was fully supported downstream. The upstream ends of the intermediate piers between adjacent gates were well rounded, and the head was measured upstream from the piers.

Columns 2 to 6 of Table II show the governing conditions of the experiments. Column 7 shows the observed discharge coefficients computed from the experimental data by Eq. (9) applicable to orifices. (See *Civil Engineering*, September, 1933, pp. 531 and 532, for Campbell and Borland's criticism of Ripley's coefficients, on the ground that they should have been computed on the basis of the head on the top of the opening. This is invalid because the coefficients as given by Ripley are computed as orifice coefficients, i.e., with the head measured to the center of the opening and are correct for this condition. They must be so computed if they are to be applied in practice as orifice coefficients. The fact that the mean velocity used in the orifice formula is not the true mean velocity through the opening is taken into account in the determination of the coefficient.)

Column 8 shows the coefficient computed by the author's Eq. (10), and column 9 shows the analytical value of the coefficient derived from Eq. (8).

It will be noted that Ripley's coefficients are certainly in agreement with the author's formula within the limits of the errors of observation. Ripley's coefficients average 3.6 per cent greater than the analytical coefficients given in column 9.

Formula (10) is offered as a practical equation for determining the discharge coefficient applicable to tainter gates.

The accompanying diagram is plotted from Eq. (8) from which the values of the analytical coefficient c_1 may be obtained directly for any depth ratio N and angle Θ. The actual coefficient C is then obtained from the relation:

TABLE I — RATIOS OF OBSERVED TO COMPUTED COEFFICIENTS, GALLEGO MILLS SLUICE-GATES

Angle of Bevel	No. of Tests	Range of N From	Range of N To	Mean N	Mean C	Mean $\frac{C}{c_1}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sharp-cornered bevels, jet in contact with lip.						
Deg. Min.						
25 – 33	3	8.79	12.74	11.27	0.8448	1.043
	3	17.56	26.40	20.75	0.8411	1.036
					Average	1.040
32 – 06	3	11.01	13.93	12.01	0.8333	1.054
	2	15.61	25.83	20.72	0.8249	1.052
					Average	1.053
36 – 34	3	5.68	7.28	6.51	0.7708	1.025
	3	8.87	9.27	9.01	0.7745	1.025
	3	11.60	14.46	12.56	0.7825	1.032
	3	16.32	25.77	20.50	0.7844	1.032
					Average	1.028
44 – 25	3	4.85	6.84	5.75	0.7245	1.014
	3	7.94	9.42	8.72	0.7403	1.029
	3	12.14	13.99	12.84	0.7380	1.021
	3	17.72	26.38	21.56	0.7409	1.020
					Average	1.021
Square-edged gates, free jets.						
90	4	4.67	5.64	5.06	0.6104	1.031
	5	5.26	6.88	6.22	0.6147	1.031
	5	7.19	8.11	7.47	0.6173	1.031
	5	8.53	9.90	9.43	0.6172	1.026
	5	11.64	15.54	13.02	0.6176	1.022
	4	18.13	27.10	22.66	0.6254	1.028
					Average	1.028
					Average of all	1.0307

TABLE II — COMPARISON OF RIPLEY'S TAINTER-GATE DISCHARGE COEFFICIENT WITH KOCH-CARSTANJEN'S COEFFICIENT AND HORTON FORMULA

No	Vertical Height of Opening, w, in Ft.	Lip Angle to Horizontal* θ, in Deg.	Depth of Water Surface to Sill D, in Ft.	Head on Center of Opening, $H = D - \frac{w}{2}$, in Ft.	Depth Ratio, $N = \frac{D}{w}$	Observed C	Horton c_1	Koch-Carstanjen c_1
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	0.77	46.0	9.00	8.62	11.7	0.76	0.738	0.716
2	1.38	48.4	9.00	8.31	6.53	0.73	0.723	0.702
3	2.10	51.0	9.00	7.95	4.29	0.70	0.707	0.687
4	2.85	53.7	9.00	7.58	3.16	0.71	0.689	0.669
5	3.65	56.5	9.00	7.18	2.47	0.68	0.667	0.648
6	4.46	59.0	9.00	6.77	2.02	0.67	0.646	0.627
7	5.38	62.5	9.00	6.31	1.68	0.60†	0.618	0.600
8	6.29	65.0	8.90	5.76	1.43	0.56	0.587	0.57

* $\sin\theta = \frac{14.7 - w}{20}$. $H = 9.00$ ft. $- \frac{1}{2}w$

† Corrected for error in discharge on original table.

$C = 1.03\ c_1$. The coefficient C is then to be applied in the formula for discharge through an orifice

$$q = CA\sqrt{2gh}$$

where q = discharge, in cubic feet per second; A = area of opening, in square feet; and h = the actual or measured head above the center of the orifice. This is the head as measured, without correction for velocity of approach.

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[2]Koch and Carstanjen, "On the Action of Water and the Forces Involved Therein," 1st Ger. ed., Berlin, 1926, pp. 100-108.

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Reinforced-Brick Columns

Data from 33 test columns indicate that strengths of steel and brickwork are directly additive, assuming steel strength up to yield point as effective

By Inge Lyse

Research Professor of Engineering Materials, Lehigh University, Bethlehem, Pa.

AN EXTENSION of the series of tests of reinforced-brick columns, reported in *Engineering News-Record* for March 16, 1933, has furnished additional data on which to base the design of brick masonry. In all, 33 columns have been tested to date, and a design formula is proposed on the basis of the test results. For small-sized vertical bars with sufficient lateral ties (¼-in. ties in every fourth joint were found to be sufficient), the reinforcement contributed its full yield-point strength to the strength of the column. With first-class workmanship under rigid inspection the strength of a reinforced-brick column may therefore be considered as made up of the strength of the brick masonry plus the yield-point strength of the vertical reinforcement. The strength formula for the reinforced brick column becomes:

$$S = k \cdot A_b f'_b + A_s f_s \qquad (1)$$

or for small percentage of reinforcement:

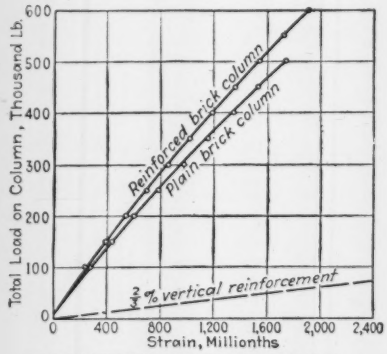
$$S = A(k \cdot f'_b + p \cdot f_s) \qquad (2)$$

where S = maximum strength of column, A = total cross-sectional area of column, A_b = cross-sectional area of brick masonry, A_s = cross-sectional area of vertical steel f'_b = crushing strength of brick, f_s = yield-point stress of vertical steel, k = effectiveness ratio of brick masonry, and p = ratio of cross-sectional area of vertical steel to that of the column.

With a factor of safety F, the permissible working stress would be:

$$f_b = \frac{1}{F}(k \cdot f'_b + p \cdot f_s). \qquad (3)$$

For ordinary masonry construction a factor of safety of 4 is considered ample, especially so when compared with the minimum factor of about 2½ for fast loading (equal to 2 for sustained load) proposed for reinforced-concrete columns by a committee of the American Concrete Institute.



LOAD-DEFORMATION DIAGRAMS show reinforced column more rigid than plain brick column by the rigidity of the vertical steel.

Effectiveness Ratio—The effectiveness ratio k depends upon the strength of the brick, the strength and plasticity of the mortar, the proportions of the column, the workmanship, the thickness of the joint and the curing of the masonry. This ratio should be determined experimentally for each job from tests on small masonry units, using the same materials, workmanship and other conditions that will be used for the actual structure. If $k = 0.25$, $f'_b = 12{,}000$ lb. per sq.in., $f_s = 60{,}000$ lb. per sq.in., $p = 0.01$, and $F = 4$, the working stress in accordance with formula (3) would be 900 lb. per sq.in.

The results of the eighteen columns tested since the previous report (*ENR* March 16, 1933) are given in the accompanying table. A deformation diagram for a plain and a reinforced-brick column, together with the diagram for the vertical reinforcement, is shown in Fig. 1. It is seen that the vertical reinforcement added its full stress value to the rigidity of the masonry, so that the curve for the reinforced column becomes very nearly equal to the sum of the curves for the plain column and the reinforcement. This reveals a marked similarity in the behavior of reinforced-brick columns and reinforced-concrete columns with respect to both deformation and ultimate strength.

The outstanding results of this investigation may be summarized as follows:

1. Portland cement mortar containing 15 per cent ordinary brick clay by weight of the cement gave higher plasticity and strength than any of the other mortars used.

2. The vertical reinforcement added its full yield-point strength to the strength of the column when sufficient lateral reinforcement was used.

3. The amount of lateral reinforcement above that needed for developing the yield-point strength of the vertical reinforcement did not have any marked effect upon the strength of the column but generally determined the type of failure. Ties of ¼-in. diameter in every fourth horizontal mortar joint were sufficient for lateral reinforcement.

4. The strength of the properly reinforced brick column may be estimated from the formula: $S = A(k \cdot f'_b + p \cdot f_s)$.

RESULTS OF TESTS OF 18 REINFORCED-BRICK COLUMNS
(Columns 12½ in. square by 10 ft. high)

Admixture in Mortar	Reinforcement, Per Cent		Maximum Load, Lb.	Maximum Strength, Lb./Sq.In.	Type of Brick
	Vertical	Lateral			
0	2½	¼-in. ties[a]	530,000	3,400	Perf. de-aired
0	2⅔	¼-in. ties[b]	452,800	2,900	Perf. de-aired
0	0	¼-in. ties[b]	479,300	3,070	Perf. de-aired
15% clay	0	¼-in. ties[b]	594,300	3,800	Perf. de-aired
5% Celite	0	¼-in. ties[b]	531,000	3,400	Perf. de-aired
5% Celite	0	¼-in. ties[b]	705,000	4,520	Perf. de-aired
5% Celite	0	¼-in. ties[b]	562,000	3,600	Solid de-aired†
5% Celite	0	¼-in. ties[b]	640,500	4,100	Solid common
15% clay	0	0	657,800	4,220	Perf. de-aired
15% clay	2½ H.Y.	¼-in. ties[b]	800,000	5,130	Perf. de-aired
15% clay	0	¼-in. ties[b]	489,200	3,140	Perf. de-aired
15% clay	0	¼-in. ties[d]	598,600	3,830	Perf. de-aired
15% clay	0	¼-in. ties[a]	609,200	3,900	Perf. de-aired
15% clay*	0	0	636,000	4,080	Solid de-aired
15% clay*	2½ H.Y.	0	690,000	4,420	Solid de-aired
15% clay*	2⅔ H.Y.	¼ in. ties[c]	800,000	5,130	Solid de-aired
15% clay*	2⅔ H.Y.	Flats[c]	659,000	4,220	Solid de-aired
15% clay*	2⅔	¼ in. ties[c]	715,000	4,580	Solid de-aired

[a]; [b]; [c]; [d]; reinforcement in every 1st, 2d, 3d, 4th joint, respectively.

*1:2 cement-sand by weight, 42 lb. net water per sack cement, all others 1:3 mortar by volume. Tested at 7 days, all others at 28 days.

†Underburned, low-strength brick.

Construction Water Supply for Colorado River Aqueduct

Project extending through desert region requires $700,000 water-supply system to provide for construction operations—Fourteen wells and seventeen booster stations on 200-mile line

By Julian Hinds
Assistant Chief Engineer, Metropolitan Water District of Southern California, Los Angeles, Calif.

TO PROVIDE water for camps and construction operations on the desert route of the Colorado River Aqueduct, a $700,000 water-supply system has been completed along the 200 miles from the river to the Coachella Valley by the Metropolitan Water District of Southern California as part of the preliminaries for the aqueduct project. The problems and obvious uncertainties involved in requiring individual contractors to provide their own water supplies in the rough desert country where wells could only be developed after careful study and exploration and the necessity for supplying the camps of the force-account operations resulted in the district's decision to provide the supply line itself. West of the Coachella Valley section existing supplies are available for construction. The problems of securing the supply, the design of the system and the construction problems are the subject of this article.

The main aqueduct is 242 miles long, made up of tunnels, cut and cover conduit, concrete-lined canals and various forms of pipe lines. Construction operations will involve 32,227,000 cu.yd. of excavation, 3,851,300 cu.yd. of concrete, 164,000,000 lb. of steel and miscellaneous metal work and the erection of five major pumping stations for the total lift of 1,600 ft. Much of the work must be done in a desert region, removed from established communications and public utility facilities. The project is divided into relatively short schedules and let to many individual contractors. It would be impracticable for each contractor to provide his own utilities and it is therefore essential for the district to build roads, power and telephone lines and the water-supply system for construction operations.

West of the Whitewater River crossing at the western end of the Coachella Valley (Fig. 1), groundwaters in quantities sufficient for construction purposes are available in many places. Also, there are occasional irrigation and domestic systems from which water may be purchased. In this region it is possible and economical to provide individual supplies, and each contractor is required to provide his own water.

East of Whitewater, potable supplies are available only at widely separated places, and individual water systems are not feasible. Beginning at Big Morongo, the next canyon east of Whitewater, a complete water-supply system has been constructed for construction work all the way to the intake on the Colorado River.

Estimate of Demand—The amount of water needed for the various construction operations was estimated on the following basis:

	Gallons
Camps, per man per day	100.00
Compressors, per 1,000 cu.ft. of free air	0.67
Drills, in tunnels, per drill per day	167.00
Mixing concrete, per cubic yard	40.00
Curing concrete—not estimated	.....
Washing aggregate per cubic yard—net loss	48.00
Subgrade wetting 1-in. depth on area covered	

Additional allowance was made for miscellaneous uses and waste, and as a further safety measure the system was designed to supply the maximum estimated daily demand in sixteen hours. No specific allowance was made for water for curing concrete, it being assumed that curing would be accomplished by other means. However, ample water is available for such water curing as may be found desirable.

Available supply

There are practically no surface waters anywhere along the aqueduct except at the Colorado River. The supply must be developed from wells. Even at the river it is simpler to pump from wells in the bottom lands than to attempt to clarify the river water. For about 50 miles east of Big Morongo the aqueduct is mostly in tunnel, along the north side of the Little San Bernardino Mountains, high above the floor of the Coachella Valley. The mountains are flanked by long porous debris slopes that permit percolating waters to escape into the valley without the accumulation of appreciable underground supplies at the higher levels. However, both the Big Morongo and Little Morongo canyons have considerable areas of water-absorbing soils above the line of the aqueduct, and good wells have been developed in each of them.

Fault lines along the base of the mountain range obstruct the movement of groundwaters in a few places, thus affording other supplies at relatively high elevation. One such well, Green's Well (Fig. 1), No. 3, was in existence prior to the beginning of the district's

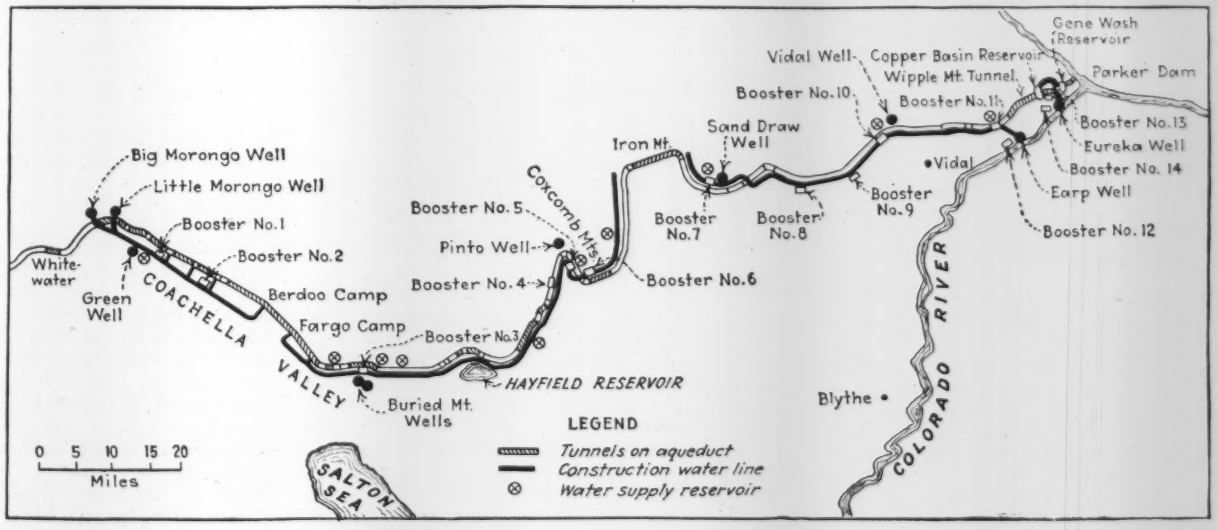


FIG. 1—MAP of western half of aqueduct line, showing location of water-supply system, wells and booster stations. For a map of the entire aqueduct see *ENR*, May 25, 1933, p. 678.

FIG. 2 (ABOVE)—Well installation, including pump house (left), aerator and tank. Installation is at Little Morongo and indicates the terrain in the Coachella Valley tunnel division.

FIG. 3 (BELOW)—Typical pumping set-up in a booster plant. The two pumps at the station operate under a 325-ft. head with a combined rated capacity of 250 g.p.m. and a 5,000-ft. maximum delivery line.

study. It has an estimated yield of about 100 g.p.m. and has been acquired by the district.

No other important high-level waters are found until the Buried Mountain Wells are reached, 45 miles farther east. At this location a broad deep alluvial valley is obstructed by a hill that has been almost submerged in debris. The escape of underground water has been retarded sufficiently to accumulate an underground pool of good quality.

East of Buried Mountain the aqueduct line passes into the desert beyond the divide of Shaver's Summit. This area is characterized by the remains of rugged mountain ranges half buried in their own debris. Underneath this debris the hard rock surface is no doubt quite irregular, and closed pockets have slowly filled from the sparse precipitation. In many basins the debris filling has not risen to the level of the water-tight rock rim, and the underground water rises to the lowest surface elevation, any excess being dissipated by evaporation. This action tends to impregnate the underground reservoir with salts to such an extent as to be unfit for use. Several wells drilled by the district encountered such supplies and had to be abandoned.

The next usable wells east of Buried Mountain are two developed in the outlet from the Pinto Basin, some 47 miles farther along the aqueduct. No usable water was found between the Coxcomb and Iron Mountains. Usable supplies were obtained at wells 13 and 14, in Vidal Wash, 67 miles farther east, and also on the river banks at Earp and near the location of the aqueduct intake.

There are eleven wells in the system at present. The estimated yield of each, dissolved solids and total hardness, are shown in Table I. All of the waters are satisfactory as to quality. Well No. 16 on the Colorado River is relatively high in total dissolved solids as a result of its location in an alkaline silt bank. This well water is distinctly more saline than the river water and will no doubt clear up with use. Well No. 15, at Earp, is more favorably situated and consequently carries less dissolved minerals. The two Morongo Wells carry considerable salt and are harder than Wells 15 and 16. The Green Well is fairly high in dissolved solids but low in hardness. All the other waters are remarkably soft for desert supplies. The Morongo Wells contain sufficient carbon dioxide to cause corrosion in the pipe lines; the condition has been relieved by the installation of aerators.

Division of system

The system is divided physically into four distinct parts. The most westerly section, supplied by the Morongo and Green Wells, feeds the Coachella division as far east as the Berdoo Camp.

East of Pushawalls the rough country forces the line down to El. 700, about 1,000 ft. below the aqueduct grade at Berdoo. If the line had extended farther east, even lower grades would have been required. Because of this topographic condition and the fact that the water available from Morongo and Green Wells is just about sufficient to supply the needs up to Berdoo, the line is discontinued at that point. However, should the yield of the three wells prove inadequate, additional supplies can be brought up from the Coachella Valley.

A much longer division serves the aqueduct from the Fargo Camp to the west portal of the Iron Mountain Tunnel, a distance of 79 miles. Water for this division comes from the Buried Mountain and Pinto Basin Wells. Because no suitable supply could be found in the basin between the Iron and Coxcomb Mountains, it was necessary to lay the supply line from the Pinto Well over the top of the Coxcombs. This requires considerable boosting but permits serving the remainder of this division by gravity.

The next division, from the east portal of the Iron Mountain Tunnel to the Colorado River at Earp, supplies 70 miles of aqueduct construction and receives water from Sand Draw, Vidal Wash and Earp Wells.

The river division extends from a well near the Parker Dam site up into the Whipple Mountains. It will supply the Gene Draw, Copper Basin and east portal of the Whipple Mountain tunnel and the pumping plant and reservoir camps.

Design of system

The pipe lines and pumping stations were designed to deliver the necessary flows at the lowest total combined investment and operating cost. The line is made up of 5-, 6-, and 8-in. light-weight welded steel pipes, of the type generally used for gas-line work. Branch lines are of 3- and 4-in. size as required. Except at drainage crossings and over rocky sections, the line is laid in trench with an 18-in. minimum cover. The longest stretch of uncovered line is across the Coxcomb Mountain, where it

is anchored on the rock at intervals of 150 to 250 ft. with anchors consisting of a strap welded to the pipe and fastened to two bolts grouted in the rock.

The pipe was bent cold in the field to fit the contour and alignment, or cut, mitered and welded as required. No expansion joints are provided, and the pipe was purposely looped or laid crooked in the trench, providing slack to take care of expansion and contraction. Where laid on the surface, the pipe was bent or sprung in a lateral arc between the anchors, the arc being supported on skids or smooth ground to permit movement of the pipe under changing temperatures. All valves and fittings are of standard design, with welding nipples for attaching into the line.

The line is generally located as close as practicable to the aqueduct; in many places it is on or immediately adjacent to the right-of-way. In the mountainous sections the line usually follows along the comparatively easy ground at the foot of the hills, with branch lines to the tunnel camps and other points of use.

For convenience in operation and maintenance, valves were installed in the line every 4 or 5 miles. Service outlets, consisting of a 3-in. valve with flange and nipple attached for welding, were installed opposite each tunnel working point and at intervals of about 10,000 ft. opposite canal and conduit section. Drain outlets were installed in low spots and air relief valves on all major summits.

The branch lines required to reach the actual points of consumption are not considered as a part of the main system and are to be installed by the individual contractors or, in case of force-account work, as a part of the construction job. A number of these branches have already been installed, and others will be needed. Only those installed by the district to supply its own camps for the Coachella tunnels are shown in Fig. 1.

FIG. 4—COMBINED WELL and booster station installation. Well house at right, with discharge tank and booster plant house in center.

Pumping equipment

The wells of the supply system are all equipped with deep-well turbine pumps varying in capacity from 150 to 750 g.p.m. and operating under heads of 60 to 530 ft. Each well pump discharges into a near-by tank that is equipped with a float valve for automatic operation of the pump. The details of this well-pumping equipment are shown in Table I.

Nineteen booster stations are required to overcome the differences in elevation and friction losses in the long delivery lines. These stations are designed as transmission boosters and provide delivery pressure only incidentally. All except two of the stations are equipped with duplicate pumping units to provide for emergencies. The booster pumps (Fig. 3) handle from 40 to 750 g.p.m. under heads varying from 160 to 800 ft. All pumps are electrically driven multi-stage centrifugal units. The details of the booster pumping stations are given in Table II. Power is supplied from the district's 66-kv. transmission line, which extends the entire length of the aqueduct.

Each booster pump is automatically controlled through time relay switches, a float-actuated cutoff valve located at a tank at the head of each section of lift line, and a flow-meter-actuated pump-motor switch at the bottom. The relay switches are set so that the pump starts as often as required to meet the demand. When the tank at the head of the line is filled, the cutoff valve there is closed and flow stops through the flow meter at the bottom. This in turn opens the pump switch and pumping ceases.

Storage Facilities—A tank is provided for each well (Fig. 4), or group of wells, to receive the discharge of the well pumps. A tank is also provided at each point of diversion from the main line, to serve as a forebay for the booster pump to the contractor's camp where the pump discharge is received in an additional terminal tank. Other tanks are provided for general storage purposes and for controlling the main-line flow.

Six of the storage tanks on the main line, of 300,000-gal. capacity each, are of the embankment type, gunite-lined and covered with redwood ship-lap roofs. The gunite is 1½ in. thick and reinforced with 6-ga., 4x4-in. welded wire mesh. All the other tanks installed by the district are of bolted or riveted steel construction. Some of the contractors are using wood-stave terminal tanks. Additional diversion and terminal tanks will be installed as more units of work are started.

Construction

The main pipe lines were constructed under three sets of specifications: (1) Big Morongo to Yellow Canyon; (2) Yellow Canyon to Sand Draw Well; and (3) Sand Draw Well to the Colorado River, including the line from Eureka Well into the Whipple Mountains. Construction was begun Jan. 30 and completed Aug. 25, 1933.

Trenching and Backfilling—Trenching on the first of these contracts was done almost entirely with a heavy road-grader drawn by a 60-hp. tractor. In easy ground two round trips completed the trench to the required 18-in. minimum depth, but an additional trip was sometimes necessary in harder or stony ground. In the worst sections a heavy single-tooth scarifier was used to loosen the ground. Some bulldozing was necessary to clear the right-of-way of boulders before trenching. An attempt was made to use a light-weight, 18-in. shovel for difficult trenching, but this proved too costly and slow and was abandoned. In general, the equipment was rather light for the job.

On the next contract, to the east, the most difficult section of the line was in

TABLE I — DATA ON WELLS AND WELL-PUMPING EQUIPMENT ON CONSTRUCTION WATER-SUPPLY SYSTEM

No.	Location	Ground Elevation	Depth of Well, Ft.	Depth to Water, Ft.	Test g.p.m.	Total Solids	Hardness	Pumping Equipment Oper. Head, Ft.	Pump Cap., g.p.m.	Pump hp.
1	Big Morongo	1,788	26	15	350	1,088	411	62	375	15
2	Little Morongo	1,618	70	56	400	882	417	124	350	20
3	Green Well	1,045	187	137	110	957	82	206	150	15
4	Buried Mt. (east)	1,320	555	244	190	355	80	400	300	50
5	Buried Mt. (west)	1,350	536	266	210	526	158	442	200	40
7	Pinto (lower)	682	452	181	450	615	47			
8B	Pinto (upper)	1,045	547	97	410	408	10	160	750	40
13	Vidal	960	785	290	100	660	74	530	150	30
14	Vidal (drilling),									
15	Earp	369	93	11	340	811	345	90	300	10
16	River	381	103	17	450	1,737	402	60	600	15

TABLE II — BOOSTER PUMPING STATIONS

Booster Station	Rated Capacity, g.p.m.	Operating Head, Ft.	Maximum Length Del. line, Ft.	No. Pumps	Pump Stages	Pump hp.
1	250	325	22,000	2	4	40
2	140	400	27,000	2	4	40
3 (west)	240	400	40,300	1	4	50
3 (west)	240	400	40,300	1	3	50
3 (east)	200	730	39,200	2	6	75
4	180	720	38,600	2	6	75
5 (west)	300	600	44,600	2	4	75
5 (east)	260	600	24,400	2	4	75
6	170	690	2,000	2	6	75
7	150	360	44,600	2	6	25
8	180	400	65,400	2	4	40
9	220	360	50,000	2	4	40
10	260	460	46,000	2	6	50
11	240	460	86,100	2	4	50
12	240	800	22,700	2	2	100
13	110	550	16,000	2	5	50
14	260	720	14,000	2	6	100
Green	150	300	5,000	1	2	25
Sand Draw	150	200	4,000	1	2	15
Buried Mountain	250	325	5,000	2	4	40

the vicinity of Cottonwood tunnel. An irrigation plow drawn by a 60-hp. tractor was tried and abandoned; a light road-grader, drawn by the same tractor, was tried and also abandoned as being too light. A heavy grader and another 60-hp. tractor were then obtained, and the two tractors in tandem were used to draw the grader. This proved a very satisfactory combination for difficult ground. Some preliminary work on the right-of-way with a bulldozer, as well as moving boulders and breaking down the banks of washes, were necessary.

A great part of the line from Yellow Canyon to Sand Draw lies in loose sandy soil. In this section a V-plow was strengthened by reinforcing with plates and braces and hooking to the two tractors. A trench about 20 in. deep was made by this combination with a single pass, and as much as 10 miles per eight-hour shift was made under favorable conditions. When the ground became so firm that the plow broke frequently or the tractors were unable to pull it at the required depth, a shallower trench was made with the plow and later deepened with the grader, or the plow was discarded and the grader alone used. Three passes, or 1½ round trips, were necessary to build the trench with the grader when two tractors were used.

On the contract for the east section to the Colorado River the methods were exactly the same—in fact, the same plow and grader were used. A more liberal use was made of the scarifier tooth in hard ground on this part of the line.

It was necessary to supplement machine operations with hand labor, digging through narrow washes and deepening in places to avoid abrupt changes in slope. Backfilling was done throughout with a 30- or 60-hp. tractor fitted with either a fixed or adjustable angle bulldozer.

Hauling and Stringing Pipe—Six-wheel trucks with two-wheel trailers were the usual equipment for hauling and stringing. Auxiliary power for rough ground and sand was supplied by tractor. In the vicinity of Cottonwood tunnel and the Eagle Mountains the pipe was stockpiled at convenient points along the road and distributed by tractor-drawn trailers.

Welding—All welding was done with acetylene. Where possible, the pipe was aligned for welding, on skids across the trench, in straight strings several hundred feet long. This work was done by a lining-up crew who also swabbed the pipe free of dirt. The welding crew followed, tack-welded the joints and then completed them. The tacks were melted and rewelded during the welding. While welding, the pipe string was rotated to provide continuous top-welding. Three or four welders with helpers were the usual crew.

The welded strings were lowered into the trench in loops to provide slack. The strings were then connected by a follow-up crew. Backfilling was done during the coolest part of the night after the remaining skids had been removed and the pipe had settled in the trench.

An acetylene generator mounted on a truck and supplying gas to three welders was used on the line from Yellow Canyon to Sand Draw Well. Although the gas produced by this equipment was cheaper than that brought in the standard containers, it is doubtful if its use resulted in much economy. Moving the equipment consumed a large part of the welders' time. The generator was frequently stuck in the sand while the whole gang worked to free it, and it also had the disadvantage of forcing a fast welder to wait for a slower one. Four generators, each supplying a single welder, were used on the eastern sections but were discarded for the remainder of the work in favor of individual gas tanks on light automobiles.

Rates of progress in welding varied greatly, depending on the character of the ground traversed. The lower limit was about 25 welded joints of 6-in. pipe per welder per eight hours, and the upper limit about 60 joints.

Bending crews accompanied the lining-up crew. Cold bends were made by: (1) man power, (2) pulling with a truck or tractor or (3) a bending machine. The bending machine consisted of a hydraulic jack inserted between the pipe and a cable, the ends of which were attached by clamps to the pipe about 5 ft. on each side of the jack. A saddle on the pipe under the jack prevented the pipe from flattening, and spreaders between the saddle and the clamps prevented the clamps from slipping. With this machine, four men could make a 15-deg. bend in about 5 min.

Testing—After welding, and before backfilling, the pipe was subjected to a hydraulic pressure of 500 lb. per sq.in. and carefully inspected. Pin holes were calked, but for any other leak the weld was cut out and the joint rewelded. Very few joints were cut out, and pin holes averaged about one per mile for the entire line. No failure of the pipe occurred at any place.

Every effort was made to obtain welders whose work was consistently good. Welders selected by the contractor were tested by a district inspector; about half the welders tested qualified. As the work proceeded, joints were cut out of the line at random intervals and tested. This furnished a constant check-up on the welders. All the work was carefully inspected, and any joint was cut out if it showed any deficiency in workmanship or strength. This was very seldom necessary, for the welders were excellent workmen.

Reservoirs—Excavation and embankment for the six 300,000-gal. reservoirs were balanced as nearly as possible. The fill was placed in 6-in. layers, and each layer was moistened and compacted with a sheepsfoot roller. Four of the reservoirs were excavated by means of two 1-yd. Fresno scrapers, each drawn by a 30-hp. tractor. This proved to be a slow and expensive method. The other two reservoirs, under the same contract were excavated with a 1-yd. gas dragline. The dragline could complete the rough excavation and embankment for one reservoir in about three days as compared to two weeks for the scrapers.

Water for all embankment was obtained from the district pipe line by arrangement with the pipe-line-testing subcontractor. No storage was provided at the work, and consequently there were numerous interruptions in the water service, but a generous supply was provided when operating, and this proved highly desirable in compacting the sand and gravel encountered.

Operation of System—All of the main water lines, including the well pumps, booster pumps and main storage reservoirs, are operated by the district, and water is sold to contractors at 15c. per 100 cu.ft. Measurement is made at the tap from the main line, and the contractor installs and operates all pipe lines, tanks and equipment required for handling the water delivered to him. He is also expected to provide sufficient storage facilities to permit shutting down the district's system eight hours daily, or longer in an emergency.

Practically all of the pipe line and the reservoirs were put into operation as soon as constructed, using gas-driven pumps temporarily. No evidence of faulty construction has appeared. The eastern part of the pipe line was constructed during the hottest season, the temperature even at night being high, and pipe line backfilled at high temperatures might be expected to give trouble as the temperature lowered. The extremely hot weather slowed up the work considerably, and the morale of the whole organization was lowered by cases of sickness from the effects of heat. This did not, however, prevent the carrying out of a thorough job.

Organization—F. E. Weymouth is general manager and chief engineer of the district, and J. B. Bond is construction engineer directly in charge of all work of this nature in the field. Valuable assistance in the preparation of this article was rendered by A. R. Baker and G. E. Archibald, assistant engineers.

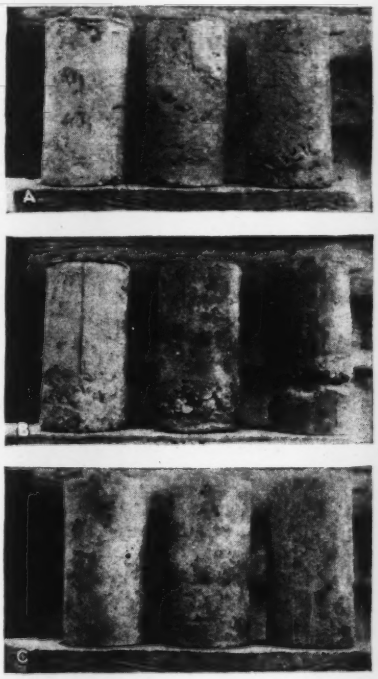
The greater part of the water-supply system has been built by contract. From Big Morongo to Yellow Canyon ($18,237 total) contract for trenching and backfilling was held by George Rowland, and laying was done by Clark, Campbell & Callahan. From Yellow Canyon to Sand Draw Well ($56,965 total) Clark, Campbell & Callahan had the contract for trenching and backfilling, with Ray Schweitzer holding the contract for laying. A $17,384 contract for reservoirs on this section was held by Macco-Robertson Co. From Sand Draw Well to the river the $24,217 contract for both trench work and pipe line was held by the Lang Construction Co. Western Pipe & Steel Co. had a $9,525 contract for three reservoirs, and the Lacy Manufacturing Co. had a $3,275 contract for steel tanks.

From Job and Office

Test on Methods of Pouring Under-Water Concrete

By Ambrose G. Hampton
Beaufort, S. C.

CONCRETE poured under water can never be subjected to the careful inspection that is accorded other concrete, and for that reason there is a question as to the best method of handling such operations. Accordingly, a series of tests was made of three methods of pouring Standard 6x12-in. molds were submerged under 2 ft. of water and were filled through a small tremie and bottom-dump bucket. With each set a cylinder was made in the dry so that comparison with standard concrete might be made. A 1:1.6:2.7 mix was used, with ¾-in maximum size of aggregate.



TOP—Cylinders poured with dump bucket. Note distribution of honeycomb and washed places. Average compressive strength is 53.6 of dry concrete.

CENTER—Cylinders poured with tremie, using usual methods of charging. Bottom of right-hand specimen is built up for testing. Average compressive strength is 9.1 per cent of dry-poured cylinder.

BOTTOM—Cylinders poured with tremie, which was charged before submerging. Average strength is 77.4 per cent of dry concrete.

Fig. 1*a* shows the three cylinders poured with the bucket, filled dry, lowered to the bottom and dumped. The compressive strength of these three cylinders averaged 53.6 per cent of that of the corresponding dry-poured cylinder. Fig. 1*b* shows three cylinders poured through a 3-in. tremie charged while in the water. Wash occurred, owing to the impossibility of charging the tremie suddenly, as would be effected in practice, with the result that the average compressive strength of the three cylinders was only 9.1 per cent of dry-poured concrete. One badly washed batch accounted for this low figure, but nevertheless unreliability of the method is indicated. In pouring the cylinders shown in Fig. 1*c*, the tremie was closed at the bottom and filled dry, then was lowered to the bottom and discharged by opening the gate. The average compressive strength of these three was 77.6 per cent of the dry-poured cylinder. It would seem that this method of charging the tremie should prove most effective in practice. In using this method, the bottom of the tremie may be raised above water until it is filled, or the bottom may be closed with a tight gate and the tremie lowered until the top is within filling range, with water excluded by the tight gate. Either method of operation will be successful in that it will keep the concrete from washing and segregation until it is dumped in place. The tests were made with the assistance of Salvadore Latorre, of the South Carolina state highway department.

Computing Paving Area at Street Intersections

By A. M. Weber
Montclair Engineering Department, Montclair, N. J.

IN CONNECTION with the work of estimates on municipal paving there was developed a short method for computing the area of paving at street corners included between the arc of the curb return and the two tangents. A formula gives the area desired (shown in the accompanying sketch) in terms of the chord length, middle ordinate and a coefficient (varying with the central angle) to be found in the table. The chord length and middle ordinate are easily measured by the field party, and the central angle is always known closely enough to use in entering the table. The development of the formula is as follows:

Let A = area of paving to be computed; C = chord length; E = external distance; M = middle ordinate; R = radius of arc; A_1 = area of segment; and Δ = central angle. Then

$$A = \tfrac{1}{2} C\,(E + M) - A_1$$

$$M = R - R\cos\tfrac{1}{2}\Delta$$

$$E = \frac{R}{\cos\frac{1}{2}\Delta} - R = \frac{R - R\cos\frac{1}{2}\Delta}{\cos\frac{1}{2}\Delta} = \frac{M}{\cos\frac{1}{2}\Delta}$$

$$A = \tfrac{1}{2} C\left(\frac{M}{\cos\frac{1}{2}\Delta} + M\right) - A_1$$

$$= \left(\frac{1 + \cos\frac{1}{2}\Delta}{2\cos\frac{1}{2}\Delta}\right) MC - A_1$$

For a given central angle there is a fixed ratio between the area of the segment and the product of the chord and middle ordinate. Denote this by X. Then $A_1 = XMC$.

$$\text{Also, } A = \left(\frac{1 + \cos\frac{1}{2}\Delta}{2\cos\frac{1}{2}\Delta}\right) MC - XMC$$

$$= \left(\frac{1 + \cos\frac{1}{2}\Delta}{2\cos\frac{1}{2}\Delta} - X\right) MC$$

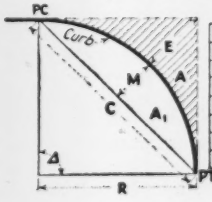
Instead of using 2/3 for the value of X from the approximate formula $A = 2/3\ MC$, a table of chords, middle ordinates and areas of segment (for unit radius) for varying central angles was used to solve for an exact value of X for various central angles. Substitution of the proper values for X and $\cos\frac{1}{2}\Delta$ for the different central angles gives us a coefficient

$$K = \left(\frac{1 + \cos\frac{1}{2}\Delta}{2\cos\frac{1}{2}\Delta} - X\right).$$

Then $A = KMC$.

The accompanying table gives values of K for central angles from 60 to 120 deg., which cover most street intersections. It may be extended to include any other central angle, or values for angles closer than 10 deg. may be obtained.

Formula and table for computing area of paving at intersections.



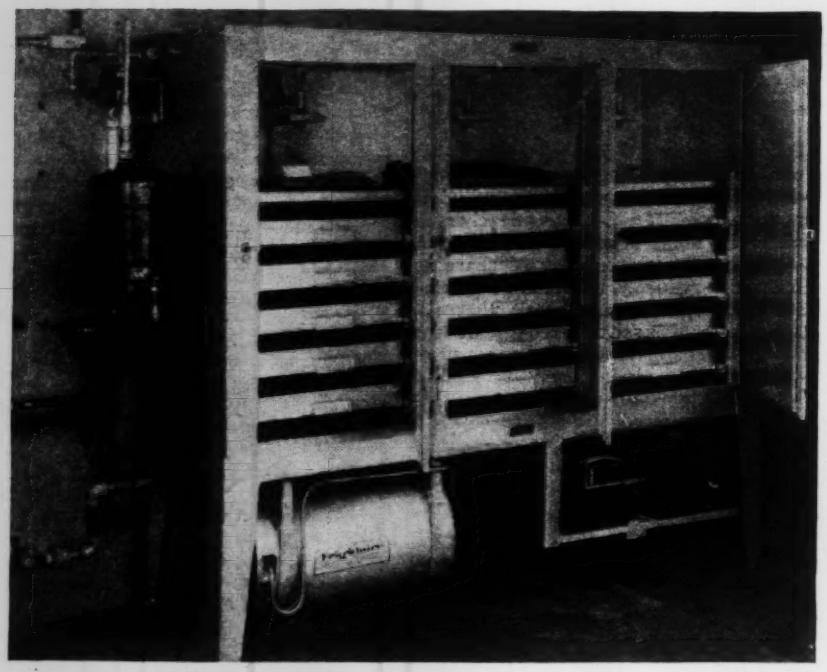
Area $A = KMC$

Central Δ·Δ	Coefficient·K
60 deg	0.40
70 "	0.43
80 "	0.47
90 "	0.52
100 "	0.59
110 "	0.67
120 "	0.79

Temperature and Humidity Control in Cement Testing

By M. Houghn
Assistant Engineer, Physical Testing Laboratory, Columbus, Ohio

THE standard method of testing cement, as adopted by the American Society for Testing Materials, requires that "The temperature of the room, the materials, the mixing water, the moist closet and the storage-tank water shall be maintained as nearly as practicable at 70 deg. F., and the mixing water, moist closet and the water in the storage tank shall not vary from this temperature more than ± 3 deg. F." It is further provided that "The relative humidity of the moist closet shall not be less than 90 per cent."



CONSTANT TEMPERATURE and humidity is maintained in the cabinet by a mechanical refrigerator, a gas-heater and a water spray.

As a result of the temperature and humidity requirements, a special constant temperature and humidity storage cabinet, as shown in the accompanying illustration, with a capacity of 75 sets of briquets (7 briquets to each set) has been designed and constructed in the physical testing laboratory of the city of Columbus. This cabinet is provided with automatic thermostatic control and has operated satisfactorily since first placed in service on Jan. 15, 1932.

The cabinet equipment includes a mechanical refrigerator, a gas heater and a thermostatic regulator. Three fine streams of water spray down on spherical surfaces located in the top of the cabinet. The resulting mist, which can be controlled by raising or lowering the spherical surfaces in the tube casings, is responsible for the humidity maintained within the cabinet. A baffle (not shown in the illustration) extending under the sprays the entire length of the cabinet prevents water from dropping down on the molds or pats. The overflow from the three sprays is carried down the back of the cabinet to the top pan under each spray. Each pan contains an overflow maintaining a 1½-in. depth of water, with the water flowing from the top pan down through each succeeding pan and thus maintaining a constant temperature of storage water. From the bottom pan the water passes out through the overflow, which has a water baffle to prevent inflow of room air through this drain. About 10 gal. of water per hour is required. With this equipment it has been possible to maintain at all times a humidity of 90 to 100 per cent and a temperature varying not more than 1 deg. above or below 70 deg. F. The cabinet as shown occupies a floor space of about 16 sq.ft.

The cabinet was designed jointly by the writer and D. H. Wyatt, engineer of the Frigidaire Corp. in Columbus, under the direction of Charles P. Hoover, chemist in charge of water purification in the division of water, Department of Public Service.

Engineering Applications of the Photo-Electric Cell

By Raymond Francis Yates
Radio Engineer, Buffalo, N. Y.

THE photo-electric cell and its attendant light source, amplifier and relay may be used to perform many tasks connected with engineering and contracting operations. The apparatus is inexpensive and will control many simple operations as a substitute for the human eye.

It has been used to make the filling of supply bins automatic. A properly shielded photo cell is mounted on the top of the bin in line with the position of the top of the contents at maximum capacity. The light source is placed on the opposite side of the bin. When the bin is filled the material will obstruct the light beam and the cell will cause a warning bell to ring. By a similar arrangement, hoppers may be filled automatically and, when filled, they may be automatically discharged. A modification of this system has been used by contractors in the mixing of concrete where weight was used to operate the cells in place of cubic capacity. A series of photo cells was placed near the beam of a scale, so arranged that when the proper amount of material was placed in the hopper the cell tripped a relay and this, operating through a second relay, stopped the flow of material.

A Buffalo contractor made good use of the photo cell. He was making a large excavation inside a fenced-off property that was very strictly guarded against intrusion owing to the secret nature of the process going on in the plant buildings. It was necessary to use a gate that was not attended, and the contractor was faced with the necessity of hiring a man to open and close the gates or stand guard to prevent the entrance of unauthorized persons. Photo cells arranged on either side of the gate, used in connection with counterweights and a small electric motor, solved the problem.

Counting automatically with a high degree of accuracy and up to speeds of 3,000 units per minute may also be done with photo cells simply by having the objects interrupt a beam of light as they pass by. In this manner, buckets, trucks, barrels or anything large enough to cut out the light source for an instant may be counted. The present devices for automatic operation of door control and floor leveling as used on the modern elevator may be modified to fit contracting requirements.

Support 42-in Storm Sewer by Novel Method

By Robert G. Blanchard
Senior Civil Engineer, New Jersey State Highway Commission

CONTRACTORS on state highway construction work in Fort Lee, N. J., used a novel method for supporting a section of 42-in. storm sewer through a muck bog. At the top a 6-ft. stratum of stable material formed a floating crust on a lower stratum of soft yielding muck or peat, and a plan was approved by the state highway commission whereby the sewer would be supported by 6x8-in. creosoted timbers placed every 6 ft. across the trench and over the pipe. These cross-timbers rested on 3x12x36-in. creosoted bearing blocks or mud sills, two at each end of the cross-timbers. The trench was backfilled to the springing line of the pipe with carefully selected material of such a nature as to give additional support to the pipe.

Corrugated iron pipe with paved invert, furnished in 18-ft. lengths, was used on this section and was suspended from the cross-timbers and brought to correct grade by means of ⅝-in. U-bars. With a crane and crew consisting of a foreman and four laborers, an average of 100 ft. of sewer was laid per eight-hour day. The contractors found this type of support much cheaper and more quickly installed than timber-piling foundation, and so far as can be

VIEW OF SEWER construction, showing timber support being set in place above corrugated iron culvert.

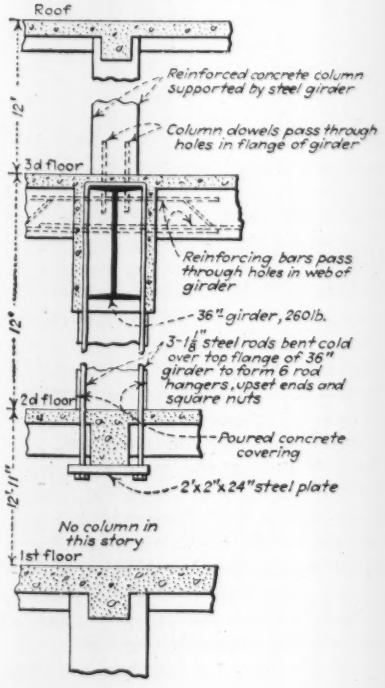
determined the sewer pipe has remained to true grade and alignment. P. Giovannone Construction Co. was the contractor on this job, and the writer was engineer for the highway commission.

Girders and Hanger Rods Substituted for Columns

By Sheldon D. Werner
Roselle, N. J.

DURING the construction of the Goodyear Tire & Rubber Co. warehouse at 66 So. 8th St., Newark, N. J., it was found necessary to omit two columns in the first story to allow large trucks to reach a loading platform within the building. The building had been designed for reinforced concrete throughout, but the girders necessary to support two floors and roof were required to withstand a bending moment of 20,000,000 in.-lb., which was impossible in concrete of limited dimensions. It was therefore necessary to use two steel girders and four steel columns, with some means of hanging the second-floor beams from above, as locating these deep girders in the second-floor framing would have interfered with the electrically operated garage doors. After much investigation the use of rods for hangers was decided on. This method allows continuity of reinforced-concrete members, simple field work and low cost. The hanger rods were bent to fit in the shop and tested to 50,000 lb. without any sign of weakness at the bend. The bearing plates were drawn up tight after the concrete forms were stripped and were covered with metal lath and plaster to allow for future inspection. The four steel columns run from 16 in. below the first floor to the bottom flange of the 36-in. girders. The entire change was made at a cost of $1,400.

STEEL GIRDER at third-floor level supports second-floor girders by steel hangers.


Roof
Reinforced concrete column supported by steel girder
Column dowels pass through holes in flange of girder
3d floor
Reinforcing bars pass through holes in web of girder
36" girder, 260lb.
3-1⅛" steel rods bent cold over top flange of 36" girder to form 6 rod hangers, upset ends and square nuts
2d floor
Poured concrete covering
2'x2"x24" steel plate
No column in this story
1st floor
12'
12'
12'-11"

Letters to the Editor

PWA Labor Classifications in Minnesota

Sir—Your editorial "Labor Classification" (*ENR*, Nov. 23, 1933, p. 633) was timely and directed attention to a matter of extreme importance to the construction industry. You are incorrect, however, in your statement that standardized wage scales and labor classifications have not been announced by agencies of the Public Works Administration other than the U. S. Bureau of Public Roads and the Corps of Engineers. Several state engineers of the PWA have made up wage scales and labor classifications for use in their respective states. This has been done to forestall so far as possible the labor disputes which you decry in your editorial. So far as I have been able to determine, there is nothing to prevent every state engineer of the PWA from formulating a proper wage scale and labor classification for his state. The National Board of Labor Review will come into the picture only in case of labor dispute.

At the outset of PWA operations in Minnesota we made and have since used a standard wage scale and labor classification on all non-federal projects. It was made after consultation with city and county officials, engineers, architects, labor leaders, contractors and others. We have had about 50 separate contracts operating under it and, to date, no labor disputes of any kind on any of these contracts have been brought to my attention. It should be obvious that it is not practicable to make a uniform wage scale and labor classification such as ours for the nation. It also should be obvious that the PWA has approached the problem in the sensible way in permitting each state organization to work out its own locally-conforming wage and classification details, all subject, of course, to revision by the National Board of Labor Review in case of dispute.

St. Paul, Minn., Dec. 4, 1933.

WM. N. CAREY,
State Engineer, PWA.

Rigid-Frame Bridges on Railroads

Sir—I have read with interest the excellent article on the Cincinnati Terminal in your issue of Nov. 2, also the editorial remarks on p. 538 about the use of the concrete rigid-frame bridge.

On the Missouri Pacific Lines there are at least seven examples of this type of structure built during the past three or four years, to span both highways and waterways, and it is possible that a similar situation obtains on other railroads.

While the advantages to be obtained are relatively less in the case of railroad bridges than in the case of highway bridges, perhaps one of the controlling considerations, from a practical standpoint, is the question as to whether or not the site is clear. It occurs to me that the usual necessity of maintaining traffic, either on an existing bridge or a temporary structure, rather than the lack of appreciation of the merits of this type of design, is the consideration that operates against its more common use in railroad practice.

S. L. WONSON,
Assistant Chief Engineer,
Missouri Pacific R.R. Co.

St. Louis, Mo., Nov. 15, 1933.

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Editorial and Publishing Offices at 330 West 42d Street, New York

January 4, 1934

Springfield Shows How

WINTER WORK going on successfully in many localities in the northern zone provides ample demonstration of the fact that construction can be carried on in cold weather without delay or undue expense when those concerned have the will to do it. Among other cold-belt cities, Springfield, Mass., furnishes a shining example of efficient handling of cold-weather construction. Not a single municipal or PWA project has been permitted to lag because of cold weather. Proper spirit and organization on the part of city engineering officials, supplemented by the physical powers of a few steam boilers on the job, keep the work under way; the desire of men to work for real wages, regardless of inconvenience, makes the work successful and efficient. Street improvements formerly regarded as a cold-weather impossibility are now routine work, and monolithic-concrete sewer construction proceeds uninterrupted, with steam sizzling from pipes in the trenches lending a cheerfulness to the jobs, matched by the enthusiasm of workmen who have long known only scanty grocery orders and free meals as their share. Springfield's experience proves that the men will turn out a good day's work if given the opportunity, and that the right attitude on the part of public officials will provide that opportunity.

New Optimism

ENTERING 1934, we find ourselves under distinctly better conditions than a year ago. The clouds that then had massed into a thunderhead on the financial horizon are fairly well dissipated, unemployment has been reduced by five or six millions, and almost every branch of industry has for several months exceeded its activity of the prior year—this being in most instances the first turn of the four-year depression. In the capital industries, where the pick-up is least marked, the bright spot is that the vital position of these industries has come to be appreciated, and they are now recognized as the agencies through which most of the remaining business deficit must be made up. Construction, major element of the capital industries group, has already been drawn upon for revival service and is ready for much greater utilization; for, though private and industrial construction will continue to languish for some time longer, public construction has vast possibilities remaining. When spring brings the Public Works Administration program up to speed, the effectiveness of construction employment as a recovery agency is certain to be more thoroughly appreciated than ever, and through this effect the cities and counties should gather new courage to push their necessary improvement projects actively. All told, the underlying facts of the business situation present a favorable picture. But above and beyond the mere statistics there is encouragement in the spirit of prudently restrained optimism with which the new year opens. It is the index of new confidence—it means a will to go ahead in place of a desire to hold back. Confidence is the source of initiative and enterprise, and these in turn are the stuff out of which prosperity is made.

No Time to Dream

IN WHAT is likely to be a short session, Congress comes together this week for work of great importance. The nation has experienced portentous developments since adjournment last June, and the obvious need now is for keenly practical consideration of the situation, preparatory to direct action in carrying forward the recovery campaign. More men must be put to work; the machinery of business needs to be rehabilitated and the channels of business flow freed of obstructions. If these things are attended to, there will be no time for dreaming or initiating dreams. Such vaporous schemes as that for the Missouri Valley Authority, of which there has been talk, have no place in present-day activities. The Tennessee Valley Authority had a solid substratum of specific construction needs, tied up with uniquely important problems of economic, agricultural and industrial character—good reasons for making practical trial of a new administrative system able to build and plan. No such condition exists in the Missouri Valley, where agriculture flourishes, industrial enterprise is adequate to the demand, and neither physical nor human reason makes regional integration imperative. To set up an Authority there would be merely to issue a mandate for dreaming. The possibilities of regional economic administration are attractive, but any new ventures should wait until the TVA experiment can make a definite showing. Present effort is better devoted to helping the TVA achieve success.

The Book Well Closed

ALLOCATIONS for several large flood-protection projects in last week's Public Works Administration list possess unusual public significance. Money was granted for the Rio Grande rectification in the El Paso reach, for a start on the Pittsburgh flood-protection system, and for building a series of impounding reservoirs on the Muskingum in eastern Ohio. These river-control enterprises, of unquestioned need and public benefit, represent the best type of construction on which to utilize idle manpower, since the control of floods is one of the most neglected fields of community safeguarding and betterment. As was witnessed only a few days ago in the Northwest and again in Southern California, catastrophic rainfalls from time to time give us a sharp lesson on the need for flood protection, but in the intervals between such visitations the matter is allowed to pass out of mind. Untold millions continue to be wasted on the navigation improvement of waterways that can never pay their keep, while flood dangers remain without attention. One reason for this is the fact that in the set-up of government functions the flood problem is nobody's business. Another is the callous notion that floods concern only the people who are flooded. The merit of the allocations above mentioned lies in the recognition of the public interest in flood protection, which undoubtedly will help to awaken the public conscience toward its responsibilities. The duty of the states in this regard is obvious, but it can better be argued out after normal business conditions

return. For the present it is enough to say that the flood-protection allocations help to close the PWA's 1933 record book in creditable fashion. The money dedicated to the purpose of creating employment by socially beneficial construction could hardly be better used.

Making Money Work

ANOTHER PWA allocation of the week attracts attention as a good investment. This is the grant of a million dollars for completing the deep-lying New York water tunnel from Hillview Reservoir under the East River to the heart of Brooklyn. The money will put to use the fifty-odd millions already invested in the tunnel, which now lie dead for lack of funds for the valves and other accessories required to put it into service. The new allocation thus represents a salvage expenditure whose financial justification needs no further proof. It also gives support to the practice of long-term community planning, for the Brooklyn tunnel is an essential part of the major plan on which New York's continued sufficiency of water service depends. As recently as three years ago it was necessary to impose rigid restrictions on water use, clear demonstration of the need for far-seeing water management and extension planning. In view of such conditions, waste control through metering and early beginning on the new supply from the Delaware River sources is highly important, but in the meantime the completion of the Brooklyn tunnel will help by providing better distribution in the large section of the city located on Long Island.

New Wine

THE WISDOM of the fathers tells us that putting new wine in old bottles may be risky. It is a good rule to remember when the modern item of steel reinforcement is introduced into the brickmason's art. The craftsman competent to proportion and build walls, arches, chimneys and corbels can build safe reinforced work only if he follows an engineer's design. Incautious enthusiasm can lead to much trouble. That was learned in the early days of reinforced concrete, when some people were so far carried away as to believe that any steel placed anywhere in any concrete would be safe for any load or stress. Test and experience are essential guides. Though even now the skilled reinforced-concrete designer can work securely in reinforced brick, Professor Inge Lyse's data on columns contribute greatly toward placing the subject on a scientific footing. But the prudent engineer will remember that there are almost as many variables in brickwork as in concrete construction; the practical factors of mortar, bedding, joints, absorption and curing claim attention. Finally, he will bear in mind as an essential consideration the broad fact that brick construction usually is called upon for a large degree of stability, and that strength is not always controlling.

Housing in 1934

AFTER the notable preparatory work done in 1933 to develop low-cost housing construction, tangible progress is due in 1934. Unless the financial and project planning so far begun is carried forward at least to partial realization, the gain represented by the vigorous new attack upon the housing problem is in danger of being lost.

Briefly, what has so far been done is provision of a means of financing low-cost housing, first through the Reconstruction Finance Corporation and later through the PWA; the passage of enabling legislation by a number of states and cities; active development of projects in a number of cities and the grant of loans to some of these by the PWA; and finally the formation of the federal Public Works Emergency Housing Corporation to undertake direct governmental construction. But there has been little actual building.

Provision of loan funds by the PWA has been found to be not the whole solution. The Detroit and Cleveland attempts to carry out housing projects ended in failure despite promised loans. Even the federal corporation has so far not made a start on construction, while on the other hand its formation served to discourage the progress of private housing.

The fundamental objective of the housing movement is too important to permit of failure, however. The public interest in adequate housing for the lowest-income groups of the population and in eliminating the worst of our slum conditions is now well established, and this public interest must be brought to practical realization by construction. That low-cost housing as well as slum clearance is essentially other than competitive and commercial was learned many years ago in Europe, and quite appropriately Sir Raymond Unwin in a public address last week emphasized the recognition given there to the public responsibility for housing conditions.

To make a corresponding advance here, housing needs a large-scale demonstration. Cleveland offers as favorable an opportunity as can be found, and for this reason the federal corporation has made a wise move in offering to take over the group of housing projects initiated there. Cleveland knows more about its housing trends and their effects on municipal costs than most cities. Its realty men appreciate the fact that decent housing to replace slums is helpful rather than hostile to the private real estate business. It has set up, with legislative aid, a municipal housing authority and has developed five projects combining slum clearance and housing to the point of federal approval. Most of the necessary land has been optioned. Thus the stage is well set for the federal government to step in and make an effective demonstration.

What can be accomplished through such a demonstration is to remove the housing question from the range of theory to that of fact. Today the concept of low-cost housing is still largely abstract and variable; vague ideas prevail in respect to slums and blighted districts; the sociological and business viewpoints are still too far apart. Success of the Cleveland undertaking as a federal project should bring several gains. Most important of them is a definition of practicable lower-third housing in terms of dollars and brickwork. Next is closer interrelation of architectural planning with community planning. Finally, more vigorous administration of sanitary and other protective measures may be brought about, which in time would make the survival of slums financially impossible and would deflate the exploitational land values that maintain them.

CURRENT NEWS

Heavy Rains Cause Serious Floods in Southern California

UNPRECEDENTED rainfall between Dec. 30 and Jan. 1, concentrated in the foothills around Los Angeles, resulted in the destruction of much property in the Los Angeles region and caused the loss of lives, estimated at about half a hundred. Details of the storm and an explanation of its wide destructive effect are given in the following telegraphic report to this journal from E. C. Eaton, chief engineer, Los Angeles County Flood Control District.

"The storm came in from the ocean and lasted 35 hours, ending at 5 a.m., Jan. 1. It was concentrated on the foothill and valley areas and not so much in the mountain regions. The total precipitation on San Gabriel at El. 4,480 was 17.8 in. In the foothill territory the rainfall varied from 11 to 11.5 in. Most of the precipitation occurred in the last sixteen hours. The maximum intensity was about one inch per hour.

"Typical flood peaks occurring at 3 a.m., Jan. 1 were: Los Angeles River at Stewart and Grey Road, 20,000 sec.-ft.; Rio Hondo at Mission Bridge, 25,000 sec.-ft.; San Gabriel River at Edison Intake, 18,000 sec.-ft.; Ballona Creek, 15,000 sec.-ft. This latter is double any previous flow of record. The Ballona Creek drainage area is 118 sq. miles, mainly street runoff.

Debris flows cause damage

"Greatest concentration of damage occurred from debris flows from the fifteen small foothill watersheds from Tujunga City on the west to Alta Canada on the east. These watersheds were denuded by the fire of last November. All have poorly defined watercourses and all discharged varying quantities of debris, by far the worst being Halls Canyon with only one and one half square miles of watershed and immediately below which is Montrose City.

"Hall Canyon at about 11 p.m. Dec. 31 started discharging large quantities of debris from the slippage of large saturated masses on the watershed and about midnight a broad wave of debris 4 ft. or more in height tore through the city totally demolishing about one hundred houses and partially demolishing about the same number. About fifty people were killed, 40 per cent being caught in houses and the remainder on the streets or caught trying to escape from the two hundred automobiles caught in debris flow.

"Damage elsewhere in the county includes 50 large bridges destroyed. Entire damage is probably $5,000,000 of which fully one half is in the Montrose area, an appalling disaster to occur from only one and one half square miles of water shed particularly considering that the district has a total of 1,500 sq.mi. of water shed.

"No serious damage occurred where permanent types of protection work have been installed. The district reservoirs collected 11,300 acre-ft. during the storm."

Bids Called for River Section of New York Vehicle Tunnel

Bids for the construction of the underriver portion of the Midtown Hudson Tunnel have been called by the Port of New York Authority, bids to be opened on Feb. 6. The Port Authority's new vehicle tunnel under the Hudson River between New York and New Jersey is to be in the neighborhood of 38th Street, Manhattan. One tube of a projected twotube tunnel is to be built at the present time with funds provided by the Public Works Administration. Contracts for the preliminary borings and for the cast iron lining were let some time ago.

The portion of the tunnel covered by the contract is approximately 6,000 ft. long, extending between the New Jersey ventilation shaft, located about 1,000 feet west of the bulkhead line, and the New York construction shaft on the south side of 39th Street between 11th and 12th avenues, and also includes the construction of about 60 ft. of rock tunnel west of the New Jersey ventilation shaft and the building of a ventilation shaft on each side of the river.

The tube will have an outside diameter of 31 ft., an outside lining generally of cast iron, but in certain places of cast steel, and an inside lining of concrete. There will be a roadway 21 ft. 6 in. wide with air ducts both below and above it.

The great part of the tunnel under the pending contract will be constructed by the shield method under compressed air. The contractor will be required to carry on his tunneling operations in both directions simultaneously, one shield moving west from the New York construction shaft and the other east from the New Jersey ventilation shaft until they meet under the river.

The New Jersey ventilation shaft, which will form the foundation, basement, subbasement and the lower portions of the air ducts of the New Jersey ventilation building, will be a steel and reinforced concrete structure constructed in an excavation in rock.

The New York ventilation or river shaft, which will form the foundation for the New York ventilation building, is to be constructed by means of a steel and concrete pneumatic caisson. The shield starting from the New York construction shaft will pass through this caisson after the caisson has reached its final position.

Construction shafts will be required on both sides of the river.

All work involved in the contract must be completed on or before March 1, 1937.

Condemnation Begun for Land for Grand Coulee Power Project

Because owners of property required for the Grand Coulee power project in Washington will not accept prices set by appraisers, the federal government has begun condemnation proceedings to acquire land needed for the project.

Flood Control Work Gets Large Grant From PWA Fund

ALLOTMENTS for flood control work totalling $28,390,000 were among the final allotments for the year 1933 totalling $83,932,000 announced by the Public Works Administration on Dec. 28.

Muskingum watershed

The Public Works Administration has allotted $22,590,000 to the Corps of Engineers to aid in financing the construction of 14 reservoirs in the Muskingum Valley in east-central Ohio. The allotment was made on the application of the Muskingum Watershed Conservancy District which had agreed to furnish an additional $22,715,000 to be used in the purchase of rights of way, flowage rights and other expenditures not directly involved in the construction of the reservoir. The Muskingum Watershed Conservancy District is a public corporation created under the Ohio conservancy law. It has authority to levy assessments based on benefits to real property and to levy maintenance assessments to operate the project.

The territory covered by the district is virtually the entire 8,000 sq.mi. of the Muskingum drainage area and 288 sq.mi. of the Duck Creek drainage area.

The proposed reservoirs will have a total capacity of more than 1,800,000 acre-ft.

Pittsburgh flood control

The sum of $3,000,000 has been allotted to the Corps of Engineers for the construction of a reservoir on the Tygart River in the Monongahela basin about two miles above Grafton, W. Va. This reservoir is to provide stream regulation and flood control of the Monongahela River and is endorsed by the Pittsburgh Flood Commission and the Tri-State Authority. It will have capacity of 327,000 acre-ft. The reservoir is one of those included in the comprehensive plan for flood control in the Pittsburgh district.

Rio Grande rectification

The State Department has been allotted $2,800,000 for rectification and stabilization work on the Rio Grande in the El Paso-Juarez Valley. Plans for the work have been developed co-operatively by the American and Mexican sections of the International Boundary Commission. The Ministry of Foreign Relations of the Mexican Government has set aside an initial appropriation of 385,000 pesos in its 1934 budget for the start of its share of the work.

A dam and reservoir is to be built near Caballo, New Mexico, 22 miles below the Elephant Butte dam. The reservoir will have a capacity of 100,000 acre-ft.

Recently the PWA allotted $433,000 to the American section of the Boundary Commission for flood control work at Nogales, Ariz.

The work in the El Paso-Juarez Valley

was described in *Engineering News-Record* Feb. 16, 1933, p. 226.

Other federal allotments include $4,143,400 to the Corps of Engineers for river and harbor improvement work, principally Miami Harbor, Fla. ($2,000,000), Missouri River dredging ($1,360,000) and at Green Bay, Wis. ($625,000); $2,300,000 to the Treasury Dept. for an extension to the Internal Revenue Building; $1,222,500 to the Office of Indian Affairs for the construction of a Land Use Institute, for repair work and for aerial surveys; $250,000 to the Alaska Road Commission for a bridge between Juneau and Douglas; and $133,000 for improvements to Wind Cove National Park in South Dakota.

Non-federal work

Allotments for state and municipal projects, 126 in number, were announced on Dec. 28. They totaled $19,271,867 and raised the total for such work past the $700,000,000 mark. The projects are given in the accompanying table. Included therein is a combined loan and grant of $4,000,000 to New York City for the construction of incinerators as part of its program to end the dumping of garbage at sea.

A sum of $27,534,000 was allotted six railroads, Southern Pacific; Illinois Central; B. & O.; Wabash; Kansas, Oklahoma & Gulf; and the Interstate R.R., chiefly for new rails.

With other allotments authorized Dec. 28, but not yet announced, the Public Works Administration has completed distribution of its $3.3 billion appropriation. PWA will not operate on a deficiency basis in anticipation of a further appropriation by Congress but will continue to prepare projects for allotment so that they may be released immediately when more funds are made available.

DETAILS OF PWA LOANS AND GRANTS FOR NON-FEDERAL WORK

Locality	Loan and Grant or Loan	Type	Man-Months Work Provided	Amount
Sulligant, Ala.	L. & G.	Sewer	840	$74,000
Sudan, Texas	L. & G.	Water Supply	22	5,000
State of Arkansas	L. & G.	Hospital	3,900	1,769,000
Winooski, Vt. (amended)	L. & G.	Sewers	450	12,857
Harmony, Minn.	G.	Waterworks	5	1,000
University of Arkansas	L. & G.	Buildings	2,250	1,165,000
West Dundee, Ill.	L. & G.	Sewage	480	82,000
Bellefonte, Pa.	L. & G.	Hospital	168	48,000
Everett, Wash. (amended)	G.	Reservoir	572	13,600
Liberty, Ky.	L. & G.	Reservoir	225	44,000
Mercer County, Pa.	L. & G.	Bridges	1,464	200,000
Georgetown, Mass.	L. & G.	Water System	520	130,000
Overland, Mo.	L. & G.	School	240	60,000
Effingham County, Ga.	L. & G.	Jail	144	26,000
Poplar, Wis.	L. & G.	City Buildings	30	10,000
Hartford, Wis.	L. & G.	Power	160	40,000
Lebanon, Ind.	L. & G.	Sewer	120	42,000
Greenville, S. C.	L. & G.	Hospital	455	140,000
North Cove, N. C.	L. & G.	School	140	68,000
Nebo, N. C.	L. & G.	School	84	33,500
Pleasant Garden, N. C.	L. & G.	School	81	34,717
McDowell County, N. C.	L. & G.	School	80	30,481
Glenwood, N. C.	L. & G.	School	75	24,000
Reidsville, N. C.	L. & G.	Disposal plant	120	23,000
Parsons, W. Va.	L. & G.	Water Supply	280	81,000
Alpena, Mich.	L. & G.	Court House	500	101,114
Union County, Iowa	L. & G.	Bridges and Roads	198	59,000
Saquin, Texas	L. & G.	Water and Light	500	130,000
Logan, Kan.	L. & G.	Waterworks	8	3,000
Afton, Okla.	L. & G.	High School	60	26,398
Van Buren, Ind.	L. & G.	Waterworks	64	12,000
Towanda, Pa.	L. & G.	Building	132	30,000
Kilgore, Texas	L. & G.	Sewage	180	30,000
Monahans, Texas	L. & G.	Sewer System	180	26,000
Gretna, La.	L. & G.	Water	1,200	269,000
Dundas, Minn.	L. & G.	Auditorium	56	8,000
East Lansing, Mich.	L. & G.	Waterworks	216	50,000
Rome, Ga.	L. & G.	Court House	175	55,000
Gower, Mo.	L. & G.	School	12	4,500
Sabetha, Kan.	L. & G.	Sewage	240	49,000
Newton, Mass.	L. & G.	Incinerator	640	200,000
Georgetown, Texas	L. & G.	Sewers	360	24,000
Milwaukee Metro. Sewerage Comm.	L. & G.	Sewage System	750	120,000
North Hempstead, N. Y.	L. & G.	Sewage System	400	125,000
Bowling Green, Ohio	L. & G.	Sewers	1,500	250,000

(Continued on the following page)

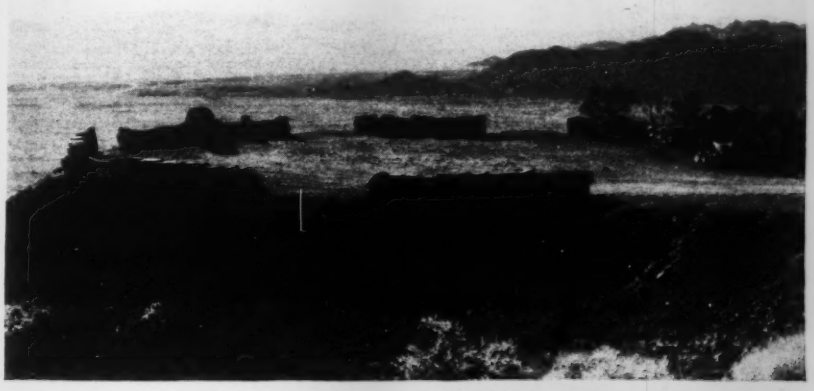
Over Half of PWA Highway Work Advertised at End of Year

At the close of 1933 highway work already advertised for contracts or started by day labor amounted to 59 per cent of the Public Works fund allotment of $400,000,000. Of the men actually at work, 102,725 were engaged on projects let to contractors and 25,928 were employed on a day-labor basis under the direct supervision of highway authorities. Awards of contracts for construction and grants of money for day labor roadwork amounted to $212,948,000. Projects completed amount to 430 and involve an expenditure of $10,961,000. The peak of employment under the Bureau of Public Roads program is expected to be reached in the spring and early summer of this year.

R.F.C. Self-Liquidating Loans Exceed Sixty Millions

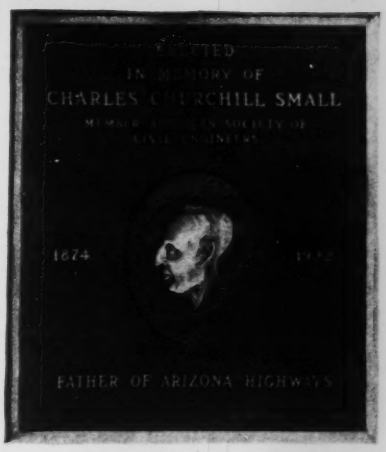
Cash advances made by the Reconstruction Finance Corporation up to November 28, 1933, to self-liquidating construction projects totaled $60,164,882. This sum includes an advance of $2,478,503 for repair and construction of buildings damaged by earthquakes, fire and tornado. Up to that date borrowers on the projects had repaid $137,175.

Cash advanced to all classes of borrowers totaled $3,543,913,394.



TABLET ERECTED IN ARIZONA HONORS HIGHWAY ENGINEER

A bronze tablet in memory of Charles Churchill Small has been erected on a boulder at Lookout Point on Yarnell Hill in Arizona by his associates in the state highway department. Mr. Small came to the Arizona Highway Department in 1919 after long experience on railroad work to become chief locating engineer, a position which he held until 1928 when he was appointed deputy state highway engineer. Mr. Small held the latter position until the time of his death in April, 1932. Mr. Small was born in North Truro, Mass., in January, 1874. At the age of fifteen he left school and went to work with a railroad engineering party at Walpole, Mass. In 1894 he went to the Southwest on account of his health and spent the greater part of the next quarter century there on railroad location and construction. From experience gained in this work Mr. Small made a notable contribution to highway development in Arizona.



DETAILS OF PWA LOANS AND GRANTS FOR NON-FEDERAL WORK

(Continued from preceding page)

LOCALITY	LOAN AND GRANT OR LOAN	TYPE	MAN-MONTHS WORK PROVIDED	AMOUNT
Cedar Rapids, Iowa	G.	School	60	$6,000
Preston, Minn.	L. & G.	Electrical System	45	21,500
Schenectady, N. Y.	L. & G.	County Home	1,800	508,000
Searcy, Ark.	L. & G.	Sewage System	160	55,000
Hoffman, Minn.	L. & G.	Waterworks	125	15,000
Gambier, Ohio	L. & G.	School	210	52,000
Oswego, Ill.	L. & G.	Water	104	19,000
Port Arthur, Texas	L. & G.	Court House	384	177,000
Marlborough, Mass.	L. & G.	Water	125	25,000
Marlborough, Mass.	L. & G.	Street	72	14,600
Salina, Kan.	G.	Sewers	105	8,300
Upper Arlington, Ohio	L. & G.	Waterworks	520	140,000
Ashland City, Tenn.	L. & G.	Waterworks	200	39,000
Randleman, N. C.	L. & G.	Waterworks	1,085	169,000
New York, N. Y.	L. & G.	Water Tunnel	10,000	1,000,000
Berkshire County, Mass.	L. & G.	Waterworks	280	74,000
Hearne, Texas	L. & G.	Waterworks	135	25,000
Starr County, Texas	L. & G.	Schools	280	59,000
Jefferson County, Kan.	G.	Bridge	22	1,800
Tippah County, Miss.	L. & G.	School	12	17,000
Palmyra, N. Y.	G.	Viaduct	1,200	82,000
Lane, Kan.	L. & G.	School	40	11,000
Jamestown, N. Y.	L. & G.	Schools	3,120	1,220,000
Heflin, Ala.	L. & G.	Waterworks	120	34,000
Battle Creek, Mich.	L. & G.	Sewage System	3,000	565,000
Des Arc, Ark.	L. & G.	Waterworks	150	41,000
Lake County, Ill.	L. & G.	School	1,560	350,000
Fort Worth, Texas	L. & G.	Viaduct	240	81,000
San Antonio, Texas	L. & G.	Sewer	900	153,000
Amarillo, Texas	L. & G.	Waterworks	1,000	186,000
Pleasant Grove, Mo.	L. & G.	School	12	3,000
Littleton, N. H.	L. & G.	Sidewalks	40	8,000
Catlin, Ill.	L. & G.	Waterworks	200	45,000
Salina, Kan.	G.	Waterworks	168	11,000
Folkston, Ga.	L. & G.	Waterworks	90	23,000
Ben Avon, Pa.	L. & G.	Streets	160	50,000
Gloucester, Mass.	L. & G.	Sewers	780	100,000
Norwood, Mass.	G.	Sewers	180	9,000
Woodbury County, Iowa	L. & G.	Schools	1040	399,000
Radcliffe, Iowa	G.	Schools	45	4,000
Waltham, Mass.	L. & G.	Streets	532	72,000
New York, N. Y.	L. & G.	Incinerators	9,000	4,000,000
New London, Conn.	G.	School	350	44,000
Anthony, Kan.	G.	Electric Plant	160	15,000
Higginsville, Mo.	G.	Water Mains	15	2,000
St. Louis, Mo.	G.	Water Supply	972	360,000
Jefferson City, Mo.	G.	Bridges	5,500	305,000
Lincoln, Ill.	G.	Streets	100	8,000
Highland, Ill.	L. & G.	School	560	194,000
Burke County, N. C.	L. & G.	Schools	500	170,000
Haverhill, Mass.	L. & G.	Streets	120	25,000
Gloucester, Mass.	L. & G.	Streets	880	120,000
Arlington, Texas	L. & G.	School	200	60,000
Brownsville, Texas	L.	Buildings	48	10,500
Lexington, Ky.	L. & G.	Sewers	10,320	1,382,000
Pawtucket, R. I.	L. & G.	Streets	285	45,000
State of Indiana	G.	Bridges	126	10,000
State of Indiana	G.	Bridges	350	24,000
Dallas, Texas	G.	Waterworks	1,107	53,000
Waltham, Mass.	L. & G.	Sewers	300	38,000
State of Indiana	G.	Bridges	140	9,000
Westborough, Mass.	L. & G.	Building	125	39,000
Waltham, Mass.	L. & G.	Bridge	165	46,000
Haverhill, Mass.	L. & G.	Sewers	165	30,000
State of Connecticut	G.	Roads	350	25,000
State of Connecticut	G.	Road	780	51,000
Portland, Me.	G.	Sewers	300	30,000
Springfield, Ill.	G.	Streets	455	35,000
Mansfield, Ohio	G.	Water Supply	80	6,000
Springville, N. Y.	G.	Water System	10	1,000
State of Massachusetts	L. & G.	Streets	720	261,000
Windsor, Conn.	G.	School	106	10,000
Windsor, Conn.	G.	Streets	598	33,000
Lyme, Conn.	G.	School	120	6,000
Washington County, Okla.	G.	School	50	2,000
State of New Hampshire	G.	Sea Wall	560	71,000
Mt. Vernon, Mo.	G.	Streets	15	2,000
Suffolk County, N. Y.	G.	Street	585	34,000
Pine Island, Minn.	G.	School	280	22,000
Cambridge, Minn.	G.	School	228	20,000
Lexington, Ky.	L. & G.	Sewage System	300	61,000
		Total....	87,112	$19,271,867

Soil Erosion Study Maps

Contracts for six aerial maps for the use of the Soil Erosion Service, Department of the Interior, have been let by Secretary Ickes. These contracts are in addition to the large maps of land in the Navajo and Zuni reservations noted in our issue of Dec. 21. Contracts for mapping in Illinois and South Carolina have been awarded to Aerial Explorations, Inc., New York, covering two projects to be mapped at a scale of 800 ft. to the inch, and contracts for mapping in Texas, Oklahoma, Missouri-Iowa, and Kansas have been awarded to J. E. King of Denver for mosaics at a scale of 500 ft. to the inch.

Survey Begun as CWA Project

The Civil Works Administration has given its approval to the making of a complete topographic survey of the ship channel at Houston, Tex., from the turning basin to Morgan's Point, covering an area about 25 miles long and 5 miles wide. Work is expected to start immediately and will employ about 40 men, chiefly engineers. An accurate map of the area has been needed for a long time for the information of industrial concerns located along the channel. Information as to the channel itself will be compiled under the direction of the U. S. Coast & Geodetic Survey.

Letting of Contract for Work on All-American Canal Opposed

Award of the contract for the first thr units of the All-American Canal proje to Six Companies, Inc., on its low bid $2,769,731 is being opposed by Mark Ro director, Imperial Valley Irrigation D trict. Mr. Rose considers the low bid t high and urges that the work be unde taken by force account. The work woul begin at Pilot Knob, near Yuma, Ariz and extend west to Sam Hills, a distanc of about 14 miles.

Secretary Ickes has warned all partie to the controversy to compose their dif ferences. He has stated that he has n intention of allowing the district to ex pend federal funds on force account.

Contract Signed for Large Loan for Pennsylvania Railroad Work

A contract through which the Pennsyl vania Railroad will obtain a loan of $77,- 000,000 to complete its electrification work between New York and Washington wa signed by the Public Works Administra tion and the railroad executives on Dec 29. Several weeks ago the PWA approved a loan of $84,000,000 to the railroad pro vided satisfactory terms could be arranged Elimination of items amounting to $7,000,- 000 has reduced the total. The loan will bear interest at 4 per cent, with no in terest charged during the first year.

About $45,000,000 will be spent for the electrification work chiefly between Wil mington and Washington, and $32,000,000 for new cars and equipment.

Montreal Water Board Outlines Extensive Construction Program

Expenditures totaling $8,135,000 are contemplated for the near future by the Montreal Water Board. The works include a reconstruction of the existing intake on the Lachine Rapids of the St. Lawrence River, seven miles of 36-in. water main, and a new 300,000,000-gallon reservoir in the Rosemount district. There has already been a great deal of discussion with regard to the last two items since a proposal has been made to award contracts for the work without calling for tenders, in the case of the watermain, considering the work as an extension of an existing contract. This suggestion has aroused much opposition. The matter is still under consideration, but is expected to come to a head at the city council meeting on Jan. 8 when the council will be asked to approve the water board budget.

Oberlin May Build Power Plant Under Ruling by Federal Court

The city of Oberlin, Ohio, may proceed with the sale of bonds voted last year for the construction of a municipal power plant, according to a decision by Judge Samuel H. West in the federal court at Cleveland, rendered on Dec. 27. The city also may operate the plant and serve its own inhabitants, according to Judge West.

West Side Elevated Highway at Chicago Adversely Reported

Engineers of the state highway department of Illinois in a report to the chief highway engineer indicate that they are not convinced that a greater return will be secured by the expenditure of money on the proposed West Side elevated highway in Chicago than could be obtained by the expenditure of an equal amount of money on the construction of modern pavements at grade in the same region, supplemented by modern traffic control facilities. The engineers state further that there is serious question as to whether or not property owners along the route of the proposed elevated structure would claim damages, no matter how much was expended on ornamentation, even along the routes having the great width of Randolph St.

The report was made by Charles E. De Leuw, acting assistant chief highway engineer, H. E. Surman, engineer of design, and Kendrick Harger, district engineer.

Increase in Business Training for Engineers at McGill

In a memorandum presented to the Corporation of McGill University at its meeting in Montreal on Thursday, Dec. 14, Dean Ernest Brown of the faculty of engineering discussed the problem faced by his faculty in correlating the studies of engineering students with the more practical aspects of their work with which they are faced after graduation, designating this for convenience as "engineering relations." Dean Brown explained that engineering law and general economics had for long been a regular part of the engineering courses at McGill, but added that in recent years the attempt had been made to extend the general training beyond that given in these courses.

These additional subjects are compulsory in the first two years. A course of lectures on the general history of science is now included in the first year curriculum, designed mainly to show that all the sciences are interrelated, and interdependent. In the second year a similar course, under the general title of "Engineering Reports" is given, this being mainly a general training in English, written and oral, as it is generally applied in the course of engineering work. Public speaking, and a general course on economic aspects of engineering, illustrated by definite examples, have been included in the third year, but as optional classes.

The most recent innovation is that provided for fourth year students during the current session for the first time, this being an optional course of weekly lectures by practicing engineers and business men on such subjects as the social sciences today: banking, insurance, labor and labor organization, sanitation (by the chief engineer of the provincial health department), safety in industry, the professional obligations of the engineer, and professional organizations (by the secretary of the Engineering Institute of Canada). Generally two lectures are given on each subject. To date, the course, although attendance is voluntary, has been attended by almost seventy per cent of the final year students. The results of the course are being followed by the teaching staff with great interest.

Bids Called for More Tunnels for Colorado Aqueduct Line

The Metropolitan Water District of Southern California has called for bids to be opened on Jan. 30 for construction of the East Eagle Mountain tunnel, 1.8 miles, and for two additional units of the Coachella tunnels, one 3.1 miles long and one 4 miles long. This is the third time that bids have been called on the East Eagle Mountain tunnel.

SOCIETY CALENDAR

ASSOCIATED GENERAL CONTRACTORS, annual convention, Washington, D. C., Jan. 29-31, 1934.

AMERICAN CONCRETE INSTITUTE, Toronto, Ontario, Canada, Feb. 20-22, 1934.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, Chicago, Ill., March 13-14, 1934.

AMERICAN ROAD BUILDERS ASSOCIATION, annual convention, Chicago, Jan. 22-26, 1934.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual meeting, New York, Jan. 17-20, 1934.

AMERICAN SOCIETY FOR TESTING MATERIALS, Atlantic City, N. J., June 25-29, 1934.

AMERICAN TOLL BRIDGE ASSOCIATION, annual convention, Cincinnati, Ohio, Jan. 26-27, 1934.

AMERICAN WOOD PRESERVERS ASSOCIATION, Houston, Texas, Jan. 23-25, 1934.

AMERICAN WATER WORKS ASSOCIATION, annual convention, New York, June 4-8, 1934.

CANADIAN CONSTRUCTION ASSOCIATION, Toronto, Ont., Jan. 22-26, 1934.

ENGINEERING INSTITUTE OF CANADA, 48th annual general meeting, Montreal, Que., Feb. 8-9, 1934.

SMOKE PREVENTION ASSOCIATION, annual convention, June 19-22, Buffalo, N. Y.

STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA at its annual meeting elected R. V. Labarre, president; Murray Erick, vice-president; Donald F. Shugart, secretary-treasurer.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 1934 regional meeting in Washington, D. C., on March 7. The meeting will feature a symposium on the outdoor weathering of metals and metallic coatings.

SAN FRANCISCO SECTION, AMERICAN SOCIETY OF CIVIL ENGINEERS, at its annual meeting elected N. A. Bowers, McGraw-Hill Publishing Co., president; Prof. C. G. Hyde, first vice-president; Walter L. Huber, second vice-president; Harold B. Hammill, secretary-treasurer.

ENGINEERING NEWS-RECORD
VOLUME 112——NUMBER 1

ENGINEERING NEWS-RECORD is a consolidation of Engineering News and Engineering Record, effected in 1917. The Contractor was consolidated with Engineering News-Record in 1918.

Engineering News was founded in 1874 by George H. Frost, as The Engineer and Surveyor, which title subsequently became The Engineer, Architect and Surveyor, then Engineering News and American Railway Journal and finally Engineering News, under the editorships of D. McN. Stauffer, A. M. Wellington and Charles Whiting Baker.

Engineering Record was established in 1877 by Henry C. Meyer as The Plumber and Sanitary Engineer. The name was subsequently changed to The Sanitary Engineer, Engineering and Building Record, and, finally, to Engineering Record. During his ownership of the paper Mr. Meyer was directly responsible for the editorial policy. John M. Goodell became editor of the paper in 1902 and was succeeded in 1913 by E. J. Mehren.

E. J. Mehren became editor of Engineering News-Record at the time of the consolidation in 1917, and was succeeded by Frank C. Wight in 1924. In July, 1928, F. E. Schmitt was appointed editor.

The editorial staff comprises: *New York:* F. E. Schmitt, editor; V. T. Boughton, managing editor; C. S. Hill, W. G. Bowman, H. W. Richardson and F. W. Herring. *Chicago:* W. W. DeBerard. *Southeast:* S. T. Henry. *San Francisco:* N. A. Bowers, J. I. Ballard.

Brief News

CONSTRUCTION OF ADDITIONAL BUILDINGS in the Fair Park at Little Rock, Ark., at an estimated cost of $500,000 is proposed by a commission appointed by the governor of the state to plan for the Arkansas centennial celebration exposition in 1936.

A RETRENCHMENT PROGRAM offered to the state highway commission of Kentucky by one of the commissioners has been rejected. Instead of cutting down its work, the highway commission, at its next meeting, is expected to consider the scaling down of salaries as an economy measure.

RADIO TELEPHONES for communication between the construction office in San Francisco and work at the various pier locations of the San Francisco-Oakland Bridge, are proving very satisfactory and economical, saving the cost of messenger service and materially aiding in speeding up the work.

CONSTRUCTION OF A $6,000,000 hydroelectric power plant and dam on the Arkansas River near Kaw City in Osage County has been recommended to the Public Works Administration by the Oklahoma department of waterways, power and flood control. The department also has recommended the creation of the Arkansas River Basin Authority with an appropriation of $50,000,000 to develop the power possibilities of the river.

WAGES INTERMEDIATE TO THOSE set by the Public Works Administration for skilled and unskilled labor have been announced by George H. Wells, state engineer of PWA for Tennessee. The PWA rates for Tennessee are 45c. per hour for unskilled and $1.10 for skilled labor. In the intermediate classifications are 80c. an hour for carpenters on rough work, 60c. an hour for apprentice helpers and 50c. for such classes of labor as mixer operators, compressor operators, pipe layers and calkers, tractor and truck operators and drill runners.

LARGELY ON THE GROUND THAT the cost of participating in the proposed metropolitan sewage disposal plan for upper Narragansett Bay municipalities in Rhode Island would be double that of independent handling and treatment, citizens of Bristol voted on Dec. 28 to complete the local program now under way by accepting a PWA loan and grant of $200,000. H. K. Barrows, consulting engineer, Boston, Mass., investigated the comparative costs of the two schemes for the town. He pointed out that adherence to the metropolitan plan would entail annual outlays ranging from $35,000 to $60,000, depending on whether Providence adhered to the project. The proposed town treatment plant provides for coarse screening, sedimentation and chlorination. A pumping station will be required in the local plan as well as in the metropolitan scheme.

FRANCHISE FOR THE CONSTRUCTION of a bridge across the Fraser River at Ladner, British Columbia, granted by the provincial legislature at a former session has been cancelled by the present government and the government has announced that it is ready to consider another application on terms considered by it to be more favorable to the public. The proposed bridge would make possible a connection between the city of Vancouver

and the U. S. Highway system at Blaine, Wash. A second company, holders of a charter for a bridge project across the Fraser River above New Westminster is making efforts to obtain approval for this project while the Ladner project is temporarily out of active consideration.

Personals

J. E. WADSWORTH has been appointed assistant chief engineer of the American Bridge Co. with offices in New York City.

DAVID W. LELLIS, consulting engineer to the highway bureau of the Long Island Chamber of Commerce, has been appointed engineer examiner on the staff of the New York State PWA.

LAWRENCE W. WALLACE, who has been executive secretary of American Engineering Council for the past 13 years, has become a vice-president of the W. S. Lee Engineering Corp. and will be in charge of the Washington office of that firm.

JOSEPH W. SHIRLEY, chairman and chief engineer of the Baltimore City Plan Commission, and head of the Bureau of Plans and Surveys, has been appointed a member of the Maryland Emergency Housing Commission, recently named by Governor Ritchie. The body is authorized to receive funds or create corporations to receive and expend funds for the elimination of slum areas, improve housing, build parks and carry on similar improvements.

HARRY D. WILLIAR, chief engineer of the Maryland State Roads Commission, and Abel Wolman, chief engineer of the Maryland Department of Health and state engineer, PWA, have been appointed members of the Maryland State Planning Commission, recently named by Governor Ritchie. The new commission is authorized to plan for future highways, parks, water supply and other improvements. Its recommendations are to be submitted to the Maryland legislature.

BENJAMIN J. CURTIS, formerly assistant engineer, Sanitary District of Chicago, has been appointed commisisoner of streets and electricity of Chicago. The position is a new one created by a consolidation of the bureau of streets formerly under the department of public works and the department of gas and electricity. Under Mr. Curtis are two deputy commissioners, Joseph J. Butler, formerly head of the bureau of street, and William D. Jackson, formerly commissioner of the department of gas and electricity. Mr. Curtis was taken to city hall to handle special assignments by Mayor E. J. Kelly when the latter was elected last spring.

Obituary

ROBERT SPENCER, superintendent of the Woburn, Mass., water department, died suddenly in that city on Dec. 28. He was 46 years of age and had been connected with the department for 20 years.

JOHN E. JOHNSON, president of the Johnson Construction Co., Buffalo, N. Y., died suddenly on Dec. 24. Mr. Johnson was 53 years of age and a native of Buffalo. He was a member of the Advisory Board of the New York State Insurance Fund.

JOHN W. WHIPPEN, formerly superintendent of the Watertown, N. Y., water department, died suddenly in that city on Dec. 26 at the age of 75. Mr. Whippen at one time had been superintendent of the Watertown public works department.

JOSEPH S. BOGGS, formerly chief engineer of the state highway commission and president of the Kentucky Concrete Pipe Co., died at his home in Frankfort on Dec. 21 at the age of 58. Mr. Boggs served as chief engineer of the highway department from 1919 to November, 1924, after which he engaged in private business.

CONSTRUCTION STATISTICS OF THE WEEK

HEAVY AWARDS for highways, public buildings and river improvements raised the total of all engineering contracts reported this week to $27,588,000, a $2,000,000 increase over the average of the past month. Road lettings amounted to nearly $10,000,000, the highest in six weeks. Another $10,000,000 of the week's awards was in federal contracts, principally for river improvements, with three large lock projects on the upper Mississippi being awarded as follows: Lock 9, Lynxville, Wis., $1,532,000; lock 22, Saverton, Mo., $1,199,000; twin locks 26, Alton, Ill., $3,195,000. Contracts for a municipal auditorium at Kansas City, $4,308,000, and for a state hospital at Manteno, Ill., $1,062,000, brought the public building award total to $6,900,000, a figure exceeded only twice in the past year. Private contracts, aggregating only $2,500,000, were the lowest in twelve months.

State, municipal and corporate new capital issues, including PWA loans, amounted to $51,759,000 for the week. Beginning with this issue, federal government allotments and appropriations for construction purposes will be added to the new capital figures, though carried separately. For the past week this item totals $36,756,000, bringing the total of all new capital to $88,515,000.

CONTRACTS
(Thousands of Dollars)

	Weekly Average Jan. 1933	Prev. 4 Weeks	Week Jan. 4, 1934
Federal Government	$3,636	$5,132	$9,948
State and municipal	15,810	12,242	15,094
Total public	$19,446	$17,374	$25,042
Total private	4,402	8,267	2,546
Week's total	$23,848	$25,641	$27,588

Cumulative to date:
1933.....$38,059 1934.....$27,588

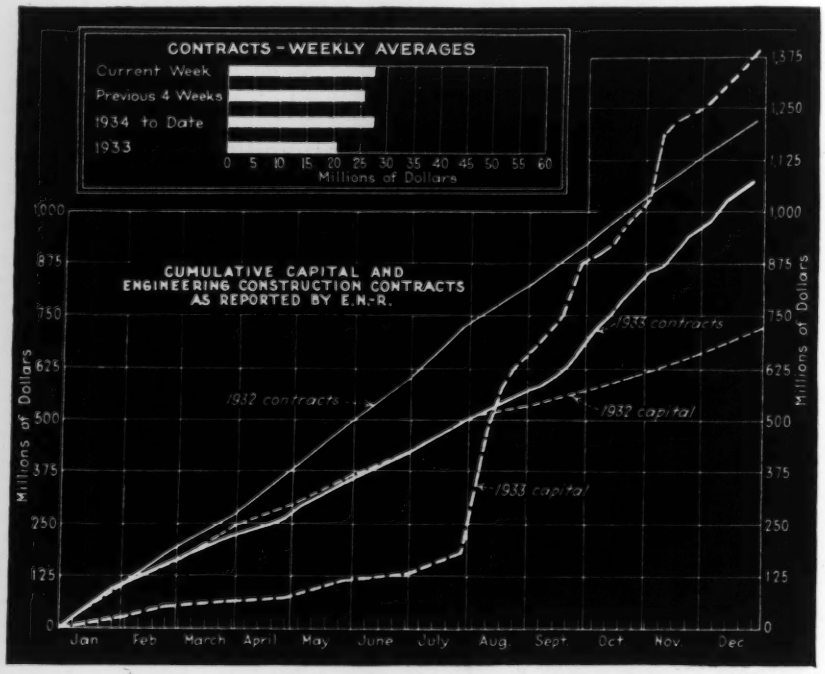
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

	Week Jan.4 1933	Cumulative 1934
State and municipal	$4,952	$4,952
PWA allotments, S&M	19,263	19,263
Corporate issues	.....	.....
PWA allotments, private	27,544	27,544
Total, Non-Federal	$51,759	$51,759
*PWA allotments Federal Const.	36,756	36,756
Total new capital	$88,515	$88,515

Cumulative Total to date:
1933....$15,550 1934....$51,759
*Not included in 1933 new capital, will be added to 1934 new capital figures.

INDEX NUMBERS

E.N.-R.-Cost		E.N.-R.-Volume	
January, 1934	191.26	December, 1933	116
December, 1933	192.14	November, 1933	133
January, 1932	158.44	December, 1932	113
1933 (Average)	170.28	1933 (Average)	102
1932 (Average)	156.97	1932 (Average)	127
1931 (Average)	181.35	1931 (Average)	220
1913 (Average)	100		


CONTRACTS - WEEKLY AVERAGES
Current Week
Previous 4 Weeks
1934 to Date
1933
0 5 10 15 20 25 30 35 40 45 50 55 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY E.N.-R.
1933 contracts
1932 contracts
1932 capital
1933 capital
Millions of Dollars
Jan Feb March April May June July Aug. Sept Oct Nov. Dec

Construction Equipment and Materials

Cast-Steel Traction Treads for Dual-Wheel Trucks

A new traction device for dual pneumatic tired trucks and tractors, known as Warco's J. & S. traction treads, has been announced by the W. A. Riddell Co., Bucyrus, Ohio. The tread consists of a series of cast-steel wearing shoes, which are linked together and set around the tires. The inside of the tread plate is a smooth surface slightly curved to fit the tire contour. They are held against the tire with sufficient tension to prevent chafing or slipping.

Warco's J. & S. traction treads

The manufacturer states that the treads are quickly and easily adjustable, having a self-locking toggle clamp with turnbuckle adjustment for compensation of tire wear or variation in tire sizes.

For extreme conditions of heavy load and icy road surfaces special "grouters" can be attached to the regular tread to further increase traction.

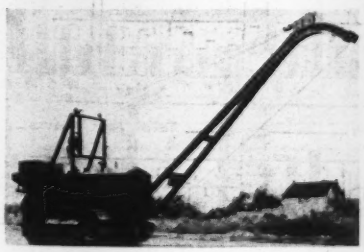
Compact Crane and Winch Mounted on Tractor

A commercial utility crane mounted on a Cletrac 20 has been introduced by the Commercial Iron Works, Portland, Ore. This equipment is a compact crane and winch unit that is adaptable to a wide range of work. The boom is of the gooseneck type which makes it possible for the crane to pick up material when it is necessary to reach forward over loads that would interfere with the boom of the more common type of crane. The crane has a lifting capacity of 2,800 lb. at a distance of 3 ft., to 1,000 lb. at a distance of 12 ft.

The boom is of the live type and can be raised or lowered to any desired position by means of a hand winch. The boom is built of structural steel, welded into a unit. By the removal of two pins and the disconnection of the topping line, the boom can be quickly removed to permit using it as a tractor unit or a regular winch unit.

Standard equipment with this unit is 50 ft. of ⅜-in. load line.

Commercial utility crane on Cletrac 20



New Equipment in Brief

Pipe-cutting machine. The Linde Air Products Co., New York, N. Y., has introduced the Oxweld pipe cutting and beveling machine. It consists of a center rod with three spreading arms which press against the inner wall of a pipe, holding it in position, with an arm supporting a blowpipe that can be adjusted to the desired angle of cut. The blowpipe and arm are rotated by a crank during the cutting operation.

Diesel locomotive. The Whitcomb Locomotive Co., Rochelle, Ill., has announced a 12-ton 0-4-0 diesel locomotive with mechanical drive. The locomotive can be built to any track gage of 30 in. or more. Power is furnished by a 6-cylinder full-diesel engine, rated at 85 hp. at 1,200 r.p.m. Transmission is by selective gears, with four speeds forward and four reverse. Drive is from a jack shaft directly to the rear axle by two chains and from rear axle to front axle by one chain. The locomotive frame is a unit casting with integral engine and transmission mounting.

Oil engine. A new oil engine for shovel and dragline service has been introduced by the Northwest Engineering Co., Chicago, Ill. It is an engine that will burn the lighter oil distillates. The manufacturer states that there are no moving parts other than those found on a gasoline engine. The pressures do not exceed those of a gasoline engine and it can be started by cranking. The operating principles are the same, it has an ignition system and a carburetor. Due to special combustion chamber design and proper manifolding, the heavy oil reaches the cylinder in practically the same condition as does gasoline.

Truck connections. A new line of truck connections, equipped with specially molded blocks of rubber to cushion shocks, has just been announced by the Fruehauf Trailer Co., Detroit, Mich. These truck connections, when installed on the rear cross member of a motor truck, enable the truck to do miscellaneous towing jobs of all kinds or to pull a 4-wheel trailer. Two types of connections are available: the hook type and the conventional clevis type. The molded rubber section, which replaces the draft spring formerly used, is completely encased against weather and dirt, and is designed to absorb the shock of either vertical or horizontal strains.

High-Speed Snow Plow

A high-speed snow plow that fits any 1½-ton truck is a recent product of the Austin Western Road Machinery Company, Chicago, Ill.

Tapered and deeply curved to pick up, spiral and throw the snow, this plow can be worked at the highest operating speeds,

High-speed plow to fit 1½-ton truck

the manufacturer states. The pronounced curve of the blade prevents the snow from clouding the windshield or clogging up the radiator of the truck. An oil pump, controlled from within the truck shaft, raises and lowers the blade. A simple attachment to the front of the truck allows quick mounting and removal.

New Publications

Surveying Instruments. David White Co., Inc., have issued a sixth edition of their catalogue and price list, covering in detailed specification their line of Transits and Levels.

Lubricants. The Acheson Oildag Company, Port Huron, Mich., has available for distribution Bulletin No. B200, dealing with "The Mechanics of Lubrication with Colloidal Graphite."

Crushing Machinery. Allis-Chalmers Manufacturing Co., Milwaukee, Wis., have available for distribution a new leaflet, No 2164, relating to brushing, screening, and washing plant machinery.

Culvert. The Toncan Culvert Manufacturers Association, Youngstown, Ohio, is releasing for distribution a 32-page handbook on "Toncan Iron Sectional Plate Pipe." Data, illustrations and detailed advantages of their recently developed product—Toncan Iron sectional plate pipe, made of copper molybdenum iron—are presented.

Conveyors. In a 36-page catalogue, the Fuller Company, Catasauqua, Pa., illustrate and describe stationary and portable Fuller-Kinyon systems for conveying dry and pulverized materials. The application of these conveyors to problems of conveying and distributing in grinding mills and process plants is separately discussed, as is the use of pumps for unloading cars and ships, with emphasis on the unloading of portland cement on construction projects.

Business Notes

MUELLER CO., Decatur, Ill., has acquired control of the Columbian Iron Works, Chattanooga, Tenn.

INDEPENDENT PNEUMATIC TOOL CO., Chicago, Ill., announces that W. A. Nugent has been appointed sales manager.

INLAND STEEL COMPANY, Chicago, Ill., has opened a sales office in Dallas, Texas, at 1511 Kirby Building. This office will have charge of sales in the state of Texas, with the exception of the city of El Paso, and in the city of Shreveport, La.

NORTHERN PUMP CO., Minneapolis, Minn., announces that Hugh L. Rusch has been elected vice-president of the company and appointed eastern sales manager. Eastern headquarters are in the Chrysler Building, New York City.

CATERPILLAR TRACTOR CO., Peoria, Ill., announces that H. P. Mee, who is now vice-president and treasurer, will be in charge of sales after Jan. 1, 1934, when George L. Bell will leave the company to become executive director of the men's clothing manufacturing industry.

Business Side of Construction

December Contracts Decline; Year's Total 88% of 1932

AWARDS for heavy engineering construction in December (four weeks) amounted to $102,563,000, or an average of 25.6 millions per week, as compared with 29.6 millions for November and 35.4 millions for October. Private contracts in December were the heaviest since last June, amounting to $33,068,000 or 8.3 millions per week, almost double the previous month's awards. Public works fell off from 24.8 millions per week in November to 17.4 millions in December, due mostly to a slacking off in federal awards which were less than half the previous month's volume. Highway lettings continued strong during December, averaging 9.2 millions per week, only a slight loss from the November average of 11.0 millions.

Heavy contracts for the year total $1,068,369,000, or 88 per cent of the 1932 volume. This closely checks the estimate made by this journal a year ago when it was predicted the 1933 volume would show a loss of 10 per cent from the 1932 total. Private construction in 1933 was almost identical in volume to that of 1932, all the loss for the year coming in public works. The increase in construction during the past six months is indicated by the fact that at the end of June only 42 per cent of the year's total had been awarded, and at that time contracts were amounting to only 74 per cent of the corresponding 1932 total. A more complete analysis of the 1933 construction volume will be presented in our annual review number.

In the geographical distribution of contracts let in December, the Middle Atlantic section again led the country with an average of 7.6 millions per week, a slight increase over the previous month's volume for this area. The Middle West district was the only other section to show an increase for December, reporting contracts averaging 4.7 millions per week as compared with a November average of 4.5 millions. In the year's award of contracts the Far West alone of the six districts of the country showed an increase over the 1932 volume.

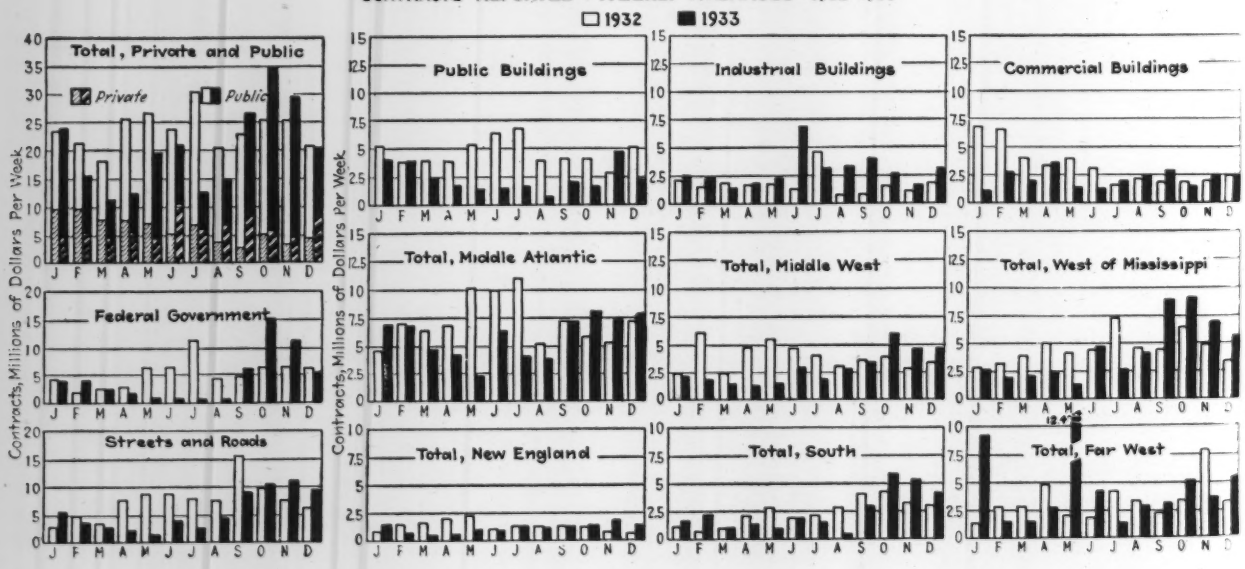
Materials notes

Prices of construction commodities have settled somewhat from the uncertain conditions prevailing for the past three months during formation of various codes. Lumber quotations for the most part correspond closely to the minimums set up in the code. Steel products show little change from previous month's quotations, except for an increase in wire. Cement prices are steady. Sand, stone and gravel quotations dropped in several localities during the month. Imported asphalt prices declined, though domestic prices showed little change.

ENGINEERING CONSTRUCTION CONTRACTS REPORTED IN DECEMBER, 1933

Four Weeks—Thousands of Dollars (000 Omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States Dec. 1933	United States Twelve Months 1933	United States Twelve Months 1932	Canada Dec. 1933
Public Works										
Waterworks	37	245	.....	579	340	248	1,449	67,263	34,586	784
Sewers	657	251	118	1,450	1,759	103	4,338	22,175	24,613	291
Bridges, public	559	235	1,193	824	1,264	475	4,550	80,890	79,557	.....
Earthwork and waterways	28	458	918	5,167	1,560	2,486	10,617	136,575	101,251	.....
Streets and roads	2,246	5,426	4,867	7,137	12,228	5,040	36,994	288,258	379,937	573
Buildings, public	609	3,616	2,388	605	1,614	613	9,445	121,161	240,627	357
Unclassified, public	132	316	560	3	1,059	82	2,152	22,817	38,014	.....
Total public	4,268	10,547	10,044	15,765	19,824	9,047	69,495	739,139	898,585	2,005
Federal gov't (included in above classifications)	594	2,498	3,635	5,622	3,357	3,385	19,091	217,180	270,866	.....
Private										
Bridges, private	.....	4,458	.....	.....	.....	.....	4,458	16,941	4,275	.....
Buildings, industrial	305	1,435	5,308	1,445	443	2,039	10,975	152,376	93,064	440
Buildings, commercial	315	7,927	.....	800	460	.....	9,502	106,399	166,296	.....
Unclassified, private	184	5,981	.....	700	1,118	150	8,133	53,514	57,089	25
Total private	804	19,801	5,308	2,945	2,021	2,189	33,068	329,230	320,724	465
December, 1933 (4 weeks)	**5,072**	**30,348**	**15,352**	**18,710**	**21,845**	**11,236**	**102,563**	.....	.....	**2,470**
November, 1933 (5 weeks)	9,660	36,967	25,775	22,653	34,194	18,197	147,446	.....	.....	6,083
December, 1932 (5 weeks)	2,880	36,147	15,012	17,020	16,927	15,374	103,360	.....	.....	2,971
Year, 1933	58,594	298,481	123,988	150,693	225,295	211,318	.....	1,068,369	.....	35,406
Year, 1932	71,636	403,830	127,815	205,423	236,205	174,400	.....	.....	1,219,309	46,616



Steel—Production of steel, which turned upward in mid-November when the output had declined to an estimated 25 per cent of capacity, continued to improve to an estimate of 35 per cent of capacity at the close of the month. According to the American Iron & Steel Institute, production of steel ingots in November, amounted to 1,540,882 tons, rated at 27.26 per cent of capacity of the industry, and brought the total of production for the first eleven months of the year to 21,057,319 tons, as compared with 12,461,799 tons for the corresponding period of 1932. November bookings of fabricated structural steel, while slightly better than those of October, continued the seasonal fourth-quarter decline, according to the American Institute of Steel Construction. Shipments for November were 23 per cent under those of October, indicating that the total business for the year will probably be 10 per cent under the low volume of 1932. The backlog of the fabricating industry at the end of November was no greater than it was at the first of the year.

Cement—The portland cement industry in November, 1933, produced 4,672,000 bbl., shipped 4,463,000 bbl. from the mills and had in stock at the end of the month 19,711,000 bbl., according to reports of the Bureau of Mines. Production in November showed a decrease of 27.7 per cent and shipments a decrease of 6.7 per cent as compared with November, 1932. Stocks at the mills were 4.9 per cent higher than a year ago. Production in November is rated at 21.2 per cent of capacity of the industry, as compared with 22.1 per cent for October and 29.1 per cent for November, 1932.

Lumber—Lumber orders steadily decreased during the last part of November and the first half of December, until the week ended Dec. 14 showed the smallest volume of new business of the year, according to the National Lumber Manufacturers Association. The decline is partly the usual seasonal trend and partly a continuance of the reaction of the buying spurt in early November. While production also declined during this period, output remained ahead of shipments, adding to the stocks at the mills.

Labor notes

The average construction wage, both skilled and common, in twenty cities throughout the country declined slightly during December, checking a steady increase that has prevailed since the first of August. The average of common wages at the first of the year was $0.5158, as compared with $0.5202 a month ago. Skilled wages dropped to an average of $1.054 from $1.062.

Construction employment during December increased considerably because of the CWA program. By the middle of December practically all of the 4,000,000 to be employed by the program were at work. Despite the work afforded by the CWA, general employment in union trades fell off in December according to estimates of the American Federation of Labor. In November the federation estimated 22 per cent of trade union workers were unemployed. Preliminary estimates for December place those out of work at 22.8 per cent of union membership. Total unemployment in November rose to 10,702,000 from the October level of 10,122,000, according to federation estimates. The Federal Employment Stabilization Board's index of employment in the production of six major construction materials stood at 42.2 for November as compared with 43.4 for October and 37.9 for November, 1932.

St. Louis—Effective Apr. 1, 1934, all union carpenters in the city will work on a 30-hour week basis. The present scale of $1.25 will be continued, while the length of work week is reduced from 40 hours. Out of a membership of 4,800, only 25 per cent of union carpenters are steadily employed at present.

Tennessee Valley—In addition to the work provided in the valley by the PWA and Tennessee Valley Authority, 16,500 more will be put to work under CWA financing, doing soil erosion correction, construction of feeder roads, rural sanitation and miscellaneous work. The work week at Norris Dam has been decreased from 44 hours to 33 hours to provide more employment. At present 1,700 men are at work on the dam.

Ohio—Although less than half of the total number of projects is under way, more than 7,600 men have found employment on Ohio's highway program.

New York—The New York state employment service reports that during November 982 applications were received for every 100 jobs offered, a 50 per cent increase over the October index and the highest of the year.

Buffalo—Results of the fifth annual study of unemployment in Buffalo indicate that in November 282 workers per thousand were unemployed, as compared with 312 per thousand a year ago. Summaries for 1933 show that 62.7 per cent of men and 16.8 per cent of women able and willing to work were employed full time, 12.2 per cent of men and 27 per cent of women were employed part time and 25.1 per cent of men and 56.2 per cent of women were unable to find work. While unemployment had decreased for male workers as compared with the previous year, it had more than doubled for women.

E.N.-R. Cost and Volume Index

The *Engineering News-Record* Construction Cost Index for January stands at 191.26, as compared with 192.14 for the previous month. This marks the first decline in the index since last June, when the rising trend was momentarily checked. The decrease this month is due entirely to a lowering of the average of construction common wages, which make up one of the four components of the index. The three commodity components of lumber, steel and cement showed no change for the month. The average of the Cost Index for 1933 is 170.28, as compared with 156.97 for 1932, though still below the 1931 average of 181.35.

The *Engineering News-Record* Construction Volume Index for December is 116, the lowest in four months. The average volume index for 1933 is 102, as compared with 127 for 1932 and 220 for 1931. The rise in construction costs accounts for the lowering of the index in a greater ratio than actual loss in construction volume for the year, as the index is based on 1913 costs and volume.

INDEX NUMBERS

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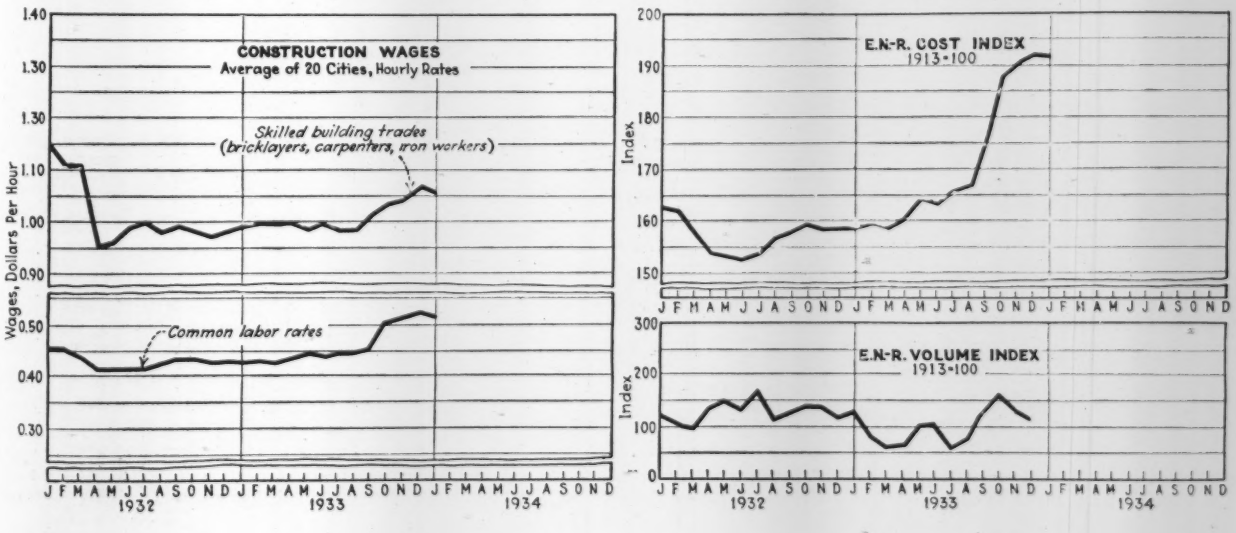

Current Prices of Construction Materials

Cement, Aggregates and Ready-mixed Concrete

	PORTLAND CEMENT — Per bbl., carload lots, f.o.b. city, including cost of bags			SAND AND GRAVEL — Per ton, carload lots, f.o.b. city			CRUSHED STONE Per ton, carload lots, f.o.b. city		CRUSHED SLAG CONCRETE		
	Cloth Bags*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	Per ton, carload lots, f.o.b. plant 1½ in.	¾ in.	Ready Mixed 1:2:4, 50c.y. more, delivered
Atlanta	$2.92	$2.67	$2.67	$1.90	$1.90	$1.45	$1.60	$1.60	$1.60	$1.60	$8.00
Baltimore	2.71	2.46	2.26	1.80‡	2.00‡	1.25‡	1.80‡	1.80‡	2.00	2.00	7.50
Birmingham	2.67	2.42	.....	3.00†‡	3.00‡†	2.40†‡	.....	.....	.80	.80	5.75
Boston	2.72	2.47	2.27	1.50	1.50	1.10	1.50	1.50	.....	.....	6.50
Chicago	2.85‡	2.60‡	2.00	2.50†	2.50†	2.25†	2.50†	2.50†	.....	.....	.....
Cincinnati	2.52	2.27	2.07	1.30	1.30	1.20	1.80	1.80	.....	.....	6.70
Cleveland	2.50	2.25	.....	1.50	1.50	1.45	1.55	1.55	1.75	1.75	7.85
Dallas	2.50	2.25	2.05	1.90	1.90	1.75	1.80	1.90	.....	.....	6.25
Denver	3.60‡	3.40‡	.....	1.85	.....	1.25	.....	.....	.....	.....	.....
Detroit	2.25	2.00	1.80	1.15	1.05	.85	.85	.85	.90	.90	5.75
Kansas City	2.90	2.65	2.20	.65	.65	.65	1.00	1.00	.....	.....	7.50
Los Angeles	2.90	2.65	.....	1.90	1.90	1.40	1.90	1.90	.....	.....	6.70
Minneapolis	2.75	.....	2.30	1.00	1.00	.25	1.00	1.00	.....	.....	7.00
Montreal	.....	1.70	.....	.....	1.50	1.35	.....	1.25	.....	.....	.....
New Orleans	2.52	2.27	.....	1.70	1.70	1.40	.....	.....	.....	.....	7.75
New York	2.90‡	2.65‡	.....	1.50†	1.50†	1.00†	1.75†	1.85†	.....	.....	8.00
Philadelphia	2.55	2.30	.....	2.00‡	2.25‡	1.80‡	1.75‡	2.00‡	1.75‡	1.75‡	6.84
Pittsburgh	2.50	2.25	1.65	1.50‡	1.50‡	1.70‡	2.25‡	2.25‡	1.25	1.25	8.25
St. Louis	2.47	2.22	.....	1.95‡	1.50‡	1.65‡	1.05‡	1.05‡	.75§	.75§	7.20
San Francisco	2.37	2.17	1.87	1.75	1.75	1.75	1.65	1.65	.....	.....	7.00
Seattle	2.90	2.65	.....	1.50†	1.50†	1.50†	.....	.....	.....	.....	5.75

*Includes 40c. per bbl. for bags, 10c. allowed for each returnable bag. †Per cu. yd. ‡Delivered. §F.o.b. Granite City, Ill.

CURRENT MILL PRICES CEMENT TO DEALERS, CARLOAD LOTS, F.O.B. MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable.

	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Alpena, Mich	$1.65	$1.60	Ironton, Ohio	$1.60	$1.55	North Birmingham, Ala	$1.75	$1.70
Buffington, Ind	1.60	1.55	Iola, Kans	1.70	1.65	Richard City, Tenn	1.85	1.80
Crestmore, Calif	1.72	.....	La Salle, Ill	1.60	1.55	Saginaw, Mich	1.65	1.60
Dallas, Tex. (Inc. 5c. tax)	1.80	1.75	Limedale, Ind	1.60	1.55	Steelton, Minn	1.80	1.75
Hannibal, Mo	1.60	1.55	Mason City, Ia	1.70	1.65	Universal, Pa	1.65	1.60
Hudson, N. Y	1.75	1.70	Norfolk, Va	1.76	1.71	Waco, Tex. (Inc. 5c. Tax)	1.80	1.75
Independence, Kans	1.70	1.65	Northampton, Pa	1.65	1.60	Wyandotte, Mich	1.60	1.55

Structural Clay Building Tile, Brick and Lime

	STRUCTURAL CLAY TILE — PARTITION — Per M, lots of 2,000 pieces or over, delivered			STRUCTURAL CLAY TILE — LOAD BEARING — Per M, lots of 2,000 pieces or over, delivered			BRICK — Per M, in quantity, delivered		LIME — Per ton, in paper, carload lots, delivered		
	3x12x12 in.	4x12x12 in.	8x12x12 in.	8x12x12 in.	10x12x12 in.	12x12x12 in.	Common backing	Straight hard	Hydrated finishing	Common hydrated	Pulverized or lump
Atlanta	$75.00	$95.00	$160.00	$208.40	$243.20	$277.90	$10.00	$10.00	$19.00	$13.00	$13.00
Baltimore	60.00	62.50	125.00	145.00	190.00	230.00	14.00	15.00	16.00	14.00	18.00
Birmingham	.....	89.00	167.00	.....	219.00	250.00	10.00	.....	.....	.....	.....
Boston	77.50	97.50	182.70	194.00	239.00	273.00	13.50	16.50	19.00	15.00	17.65
Chicago	62.25	66.40	91.30	.....	.....	.....	9.20	10.20	18.00	18.00	16.00
Cincinnati	44.25	53.80	98.00	113.20	149.10	169.40	11.00	13.50	15.20	11.20	.....
Cleveland	45.00	48.00	90.00	117.00	136.50	156.00	16.00	16.00	18.00	16.00	2.60§
Dallas	82.75	90.00	163.50	196.00	195.75	233.00	.....	15.50	20.00	19.00	2.50§
Denver	75.00	80.00	135.00	135.00	185.00	220.00	11.75	25.50	18.00	16.00	2.60§
Detroit	60.00	64.00	120.00	170.00	200.00	250.00	11.50	12.00	20.00	20.00	16.00
Kansas City	62.50	75.00	140.50	155.00	.....	.....	13.50	18.00	.55‡	.50‡	2.50§
Los Angeles	77.50	94.25	134.00*	188.00	232.50	311.50	11.50	.....	18.70	.....	19.70
Minneapolis	77.00	84.00	143.00	165.00	173.00	240.00	10.00	18.00	25.50	21.00	21.00
Montreal	.....	110.00	.....	.....	260.00	.....	19.00	32.00	20.00	16.00	16.00
New Orleans	58.40	62.30	116.90	159.20	194.60	.....	13.00	.....	23.00	12.50	1.95§
New York	81.00	86.00	129.00	193.30†	238.80†	295.60†	12.75	.....	19.00	15.00	20.00
Philadelphia	78.00	85.00	160.00	195.00	235.00	295.00	15.00	18.00	14.60	11.00	10.50
Pittsburgh	44.00	48.00	95.00	106.00	118.00	143.00	15.00	20.00	16.25	15.25	17.20
St. Louis	57.00	60.00	110.00	130.00	150.00	190.00	14.00	16.00	.55‡	.45‡	2.40§
San Francisco	68.00	76.50	174.00	.....	.....	.....	14.00	16.00	22.50	19.00	15.50
Seattle	80.00	87.00	200.00	.....	.....	.....	14.00	16.00	30.00	25.00	3.00§

*6x12x12 in. †F.o.b. Perth Amboy, N. J. ‡Per sack. §Per bbl.

Road Surfacing Materials

	PAVING BRICK AND BLOCKS			ASPHALT BINDERS — FLUXES				CUTBACK ASPHALT		ROAD OILS	ASPHALT EMULSION	
	Granite Blocks per M, lots of 50,000, 4x8x4 in., f.o.b. city	Brick per M, 3x8½x4 in., carload lots f.o.b. city	Wood Blocks per sq.yd., 3½ in., 16-lb. treat, f.o.b. city	PAVING ASPHALT Per ton, less than 80 penetration, f.o.b. city Tank car	Drums	Per gal., 80-300 penetration, f.o.b. city Tank car	Drums	Per ton, f.o.b. city Tank car	Drums	Per gal., f.o.b. city Tank car	Per gal., f.o.b. city Tank car	Drums
Atlanta	$3.00*	$35.00	$2.25	$18.20	$23.41	$0.0728	$0.989	$20.45	$27.22	$0.0728	$0.105	$0.105
Baltimore	135.00	43.00	2.00	17.00	22.00	.07	.095	.08†	.115†	.065	.....	.....
Birmingham	65.00	25.00	.....	11.00	.....	.....	.....	.....	.....	.....	.06	.....
Boston	75.00	32.00	2.00	14.00	18.00	.055	.09	.07†	.105†	.055	.09	.145
Chicago	145.00	42.00	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cincinnati	115.00	37.00	....	17.00	21.00	.09	.....	18.00	.....	.07	.08	.11
Cleveland	125.00‡	37.50	....	16.00	18.50	.0948	.1448	15.00	21.00	.62	.065	.10
Dallas	.....	25.50	....	16.45	21.10	.0584	.0809	19.60	25.00	.0484	.1384	.1684
Detroit	.....	34.50	....	14.29	16.88	.....	.....	13.94	17.94	.....	.....	.....
Kansas City	32.00	28.00	2.75	12.00	18.00	.05	.09	.07	.11	.05	.06	.09
Los Angeles	.....	48.50	....	12.00	16.00	12.00#	16.00#	14.00	.....	.042	.0525	.1125
Minneapolis	.....	.....	2.50	17.30	21.30	.065	.105	19.60	32.20	.048	.....	.....
Montreal	.....	100.00	....	14.00	19.66	.07	.093	19.00	26.50	.07	125.00	.155
New Orleans	200.00	35.00	....	13.00	18.00	.....	.....	.....	.....	.....	.....	.....
New York	135.00	47.50	2.05	17.00	22.00	.07	.095	.08†	.115†	.065	.085	.12
Philadelphia	115.00	45.00	2.02	11.00	17.00	.....	.....	.....	.....	.....	.....	.....
Pittsburgh	115.00	35.00	....	19.00	24.00	.0775	.1125	.086†	.121†	.0675	.....	.....
St. Louis	2.75*	35.00	2.00	17.50	21.50	.0675	.....	.....	.....	.035	.095	.....
San Francisco	.....	45.00	....	12.00	18.00	12.00#	18.00#	14.00#	21.50#	.04	.08	.12
Seattle	.....	47.50	....	18.00	23.10	18.00	23.10	15.00	.....	.02	19.20#	34.20#

Note: Paving asphalt, tank car or boat, f.o.b. Maurer, N. J., per ton, Bermudes, $25.00; Trinidad, $21.00. *Per sq. yd. †Per gallon. ‡4½x6x5½in #Per ton

Current Prices of Construction Materials

Iron and Steel Products—Base Mill Prices

	STRUCT. SHAPES-PLATE Per 100 lb., carload lots	REINF. BARS Per 100 lb., ¾-in. billet, carload lots	RIVETS Per 100 lb., ¾-in. structural carload lots	WIRE NAILS Per 100 lb., base, carload lots	SHEET PILING Per 100 lb., base, carload lots	STEEL RAILS Per Gross Ton: Standard	STEEL RAILS: Light	STEEL RAILS: Re-rolled	TRACK SUPPLIES Per 100 lb., carload lots: Angle bars	Std. spikes	Tie plates	Track bolts
Birmingham	$1.85	$1.95	.....	$2.35	.....	$36.375	$32.00	$31.00	$2.55	$2.40	$1.90	$3.55
Chicago	1.75	1.95	$2.85	2.35	$2.00	36.375	32.00	31.00	2.55	2.40	1.90	3.55
Pittsburgh	1.70	1.90	2.75	2.35	2.00	36.375	32.00	.....	2.55	2.40	1.90	3.55

Iron and Steel Products—Local Prices f.o.b. Warehouse

	STRUCTURAL SHAPES Per 100 lb., base price	REINFORCING BARS Per 100 lb., ¾ in., base price: New billet	REINFORCING BARS: Rail steel	EXPANDED METAL LATH Per 100 sq.yd., carload lots: Std. diamond mesh, 3.4 lb.	EXPANDED METAL LATH: Std. ribbed 3.4 lb.	WELDED FABRIC REINFORCING Per 100 s.f., carload lots: 4x16 in., No. 5 & 10 wires	WELDED FABRIC REINFORCING: 4x12 in., No. 8 & 12 wires	WELDED FABRIC REINFORCING: 6x6 in., No. 6 & 6 wires Per sq.yd.	SHEET PILING Per 100 lb. base price
Atlanta	$3.34	$2.17	$2.02	$19.50	$22.00	$1.60	$1.21	$0.151	$2.45
Baltimore	2.85	2.60	2.40	22.00	24.00	1.46	1.12	.137	2.40
Boston	3.42	2.82	2.35	20.25	24.25	1.50	1.14	.142	2.40
Chicago	3.60	2.43	.....	20.50	24.00	1.46	1.12	.137	2.00
Cincinnati	3.30	3.10	3.10	20.50	23.50	1.44	1.11	.135	.....
Cleveland	2.90	2.90	2.45	15.40	17.40	1.44	1.11	.135	.....
Dallas	3.85	3.60	3.50	27.75	32.50	1.79	1.27	.161	.....
Denver	3.29	3.54	.....	23.00	27.00	1.79	1.27	.161	.....
Detroit	3.30	2.985	2.85	15.00	19.00	1.48	1.13	.139	2.885
Kansas City	3.65	2.82	2.50	24.50	.....	1.54	1.17	.145	2.50
Los Angeles	2.95	2.80	.....	25.00	30.00	2.00	1.40	.18	2.50
Minneapolis	3.15†	2.67†	2.52†	20.50†	24.00†	1.66	1.20	.149	2.40†
Montreal	3.25	3.00	2.80	.....	.....	.....	.....	.....	3.30
New Orleans	3.50	3.00	.....	19.50	23.00	1.58	1.20	.149	.....
New York	3.27	2.57	2.42	20.50	24.00	1.53	1.18	.139	.....
Philadelphia	2.60	3.00	.....	18.50	22.00	1.44	1.11	.135	2.28
Pittsburgh	1.70‡	1.80‡	1.75‡	17.00‡	22.00‡	1.44	1.11	.135	2.00‡
San Francisco	3.25	3.15	2.95	21.50	24.50	1.90	1.40	.18	2.40
Seattle	3.40	3.50	.....	.....	.....	1.90	1.40	.18	.....
St. Louis	3.34	2.29	2.14	24.80	28.00	1.46	1.12	.137	.....

†F.O.B. City. ‡Base Mill Price. Note: Shapes, bars and piling subject to quantity discounts.

Paints and Roofing Supplies

	WHITE LEAD Per 100 lb. keg in oil, f.o.b.	READY-MIXED PAINT Per gal., drums, f.o.b.: Graphite*	READY-MIXED PAINT: Aluminum†	READY-MIXED PAINT: Ferric Oxide‡	ROOFING SUPPLIES Carload lots, f.o.b. city: Rolls, slate surfaced, 85-90 lb., per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating, per gal.	Tar pitch, 350-lb. bbl., per ton
Atlanta	$11.75	$1.60	$1.10	.....	$1.94	$3.02	$3.30	$0.37	$22.80
Baltimore	11.00	1.25	2.10	$1.90	1.90	2.60	2.50	.50	27.00
Boston	11.00	1.05	1.80	1.50	1.85	2.50	2.50	.6625	23.00
Chicago	11.00	1.85	2.25	1.25	1.60	1.50[s]	1.50[s]	.24	20.00
Cincinnati	11.00	1.40	3.00	1.55	2.40	2.25[s]	2.25[s]	.36	25.00
Cleveland	11.00	1.65	2.35	.....	1.65	47.50°	47.50°	.33	19.50
Dallas	12.00	1.90	2.10	1.50	2.17	1.98[s]	2.08[s]	1.55§	33.00
Denver	11.12½	.....	2.55	.....	2.75	3.46	3.46	.60	30.00
Detroit	11.00	1.55	2.40	1.30	1.57	2.31	2.50	.40	27.00
Kansas City	11.12½	1.50	2.10	1.30	1.65	1.75	2.00	.30	25.00
Los Angeles	10.75	1.60	2.25	2.30	2.00	1.50	.....	.45	.....
Minneapolis	11.12½	.....	.....	.....	1.60	1.50	1.50	.2925	23.30
Montreal	9.75	.....	.....	.....	.....	2.62	2.02	1.40§	1.63§
New York	11.00	1.70	2.15	1.42	.....	.....	.....	.....	.....
Philadelphia	11.00	.....	.....	.....	1.60	1.50	1.50[s]	.29	20.00
Pittsburgh	11.00	1.05	1.95	.80	1.90	1.65[s]	1.65	.31	23.00
St. Louis	11.00	1.85	2.25	1.25	1.88	2.73	2.73	.46	26.00
San Francisco	10.75	.....	.....	.....	.....	.....	.....	.45	.....
Seattle	10.75	.....	1.92	.....	3.10	4.50	.....	.54	27.60

*New Jersey State Hwy. Spec. 120M. †ASTM Spec. D266-31. ‡80% maximum ferric oxide. °Per ton. §Per 100 lb. [s]Per roll.
Note: Red lead dry, same as white lead in oil, red lead in oil 50c higher.

Miscellaneous Items

WINDOW GLASS

Discounts from latest jobbers list, Sept. 15, 1928

	Single or Double Thickness: A quality	B quality
Atlanta	85%	85%
Baltimore	88%	90%
Birmingham	89%	91%
Boston	88%	90%
Chicago	87%	89%
Cincinnati	.....	.....
Cleveland	80%	85%
Dallas	.....	.....
Denver	84@ 5%	86@ 5%
Detroit	87@10%	89@10%
Kansas City	89@10%	89@10%
Los Angeles	90%*	90@40%*
Minneapolis	84%	86%
Montreal	.....	.....
New Orleans	87@10%	96@10%
New York	87%	89%
Philadelphia	88@10%	90@10%
Pittsburgh	86%	88%
St. Louis	87%	89%
San Francisco	90%	90@30%
Seattle	90@10%	90@20%

*Disc. from list Aug. 1, 1929. †F.o.b. Arsenal.

EXPLOSIVES

Per lb. dynamite delivered 50-lb. cases

	Gelatin 40%	Gelatin 60%
Atlanta	$0.215	$0.2375
Baltimore	.19	.20
Birmingham	.15	.1725
Boston	.2225	.2375
Chicago	.17	.195
Cincinnati	.22	.245
Cleveland	.1825	.1975
Dallas	.30	.35
Denver	.19	.205
Detroit	.237	.255
Kansas City	.16	.18
Los Angeles	.1725†	.1925†
Minneapolis	.1725	.1875
Montreal	.1675	.1925
New Orleans	.19	.22
New York	.23	.245
Philadelphia	.215	.24
Pittsburgh	.1175	.1325
St. Louis	.1375	.1525
San Francisco	.1575	.1725
Seattle	.1525	.1675

CHEMICALS

Water, sewage treatment, road work, f.o.b., carlots, New York:	
Bleaching powder, in drums, f.o.b. works, per 100 lb.	$1.90
Calcium chloride, 77-80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, f.o.b. works, freight equalized with points of competition, per ton	19.50
Chlorine, cylinders, per lb. delivered	.05½
Silicate of soda, 60 deg., in drums, f.o.b. works, per 100 lb.	1.65
Soda ash, 58%, in bags, per 100 lb.	1.25
Sulphate of aluminum, in 100 lb. bags	1.35@1.50
Sulphate of copper, in bbl., per 100 lb.	3.75

PILES

Prices of Nichols Bros., 90 West St., N. Y. C., per linear foot, pine, with bark on, f.o.b., New York; delivered from barge, 1¼ to 2c, per ft. additional:

Dimensions	Points	Length	Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.09	$0.145
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.13	.195
12 in.—2 ft from butt	6 in.	60 to 69 ft.	.15	.215
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.185	.225
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.2025	.225
14 in.—2 ft. from butt	5 in.	80 to 85 ft.	.265	.375
14 in.—2 ft. from butt	5 in.	85 to 89 ft.	.305	.442

RAILWAY TIES

Prices f.o.b., per tie, for carload lots:		6 In. x 8 In. by 8 Ft.	7 In. x 9 In. by 8½ Ft.
Boston	Oak, untreated	$0.90	$1.20
	Pine, untreated	.90	1.20
	Pine, creosoted	1.35	1.85
New York	Long-leaf sap pine, untreated	.80	1.00
	Mixed oak, untreated	.....	1.00
Birmingham	White oak, untreated	.75	1.50
	White oak, creosoted	1.40	1.45
	Southern pine, untreated	.35	.60
	Southern pine, creosoted	.95	1.35
Chicago	White oak, untreated	1.15	1.35
	Oak, empty cell, creosoted	1.50	1.80
	Oak, zinc treated	1.40	1.65
	Southern pine, creosoted	1.35	1.50
Los Angeles	Fir, untreated	.64	.89
	Fir, creosoted	1.84	2.59
Philadelphia	Red oak, untreated	1.00	1.20
	Red oak, creosoted	1.50	1.85
	White oak, untreated	1.10	1.55
St. Louis	Red oak, untreated	1.00	1.45
	Red oak, creosoted	1.40	1.95
San Francisco	Sap Pine or cypress, untreated	.90	1.25
	Douglas fir, green, untreated	.45	.63
	Douglas fir, empty cell, creosoted	1.14	1.56
Montreal	Birch or maple, untreated	1.00	1.00
	Birch or maple, creosoted	1.25	1.55

Current Prices of Construction Materials

Water, Sewer and Drain Pipe

	C. I. PIPE Per net ton, f.o.b. 6 in. and over b. & s. class B and heavier, C/L lots*	VITRIFIED SEWER PIPE Per foot, delivered, standard 8 in., s.s.	12 in., s.s.	24 in., d.s.	36 in., d.s.	CLAY DRAIN TILE Per 1,000 ft., carload lots, f.o.b. 6 in.	8 in.	CONC. SEWER PIPE Per ft., delivered; ASTM Spec. C 14-24 12 in.	24 in.	WROUGHT STEEL PIPE Full std. weight. Discounts from standard list for delivery from warehouse, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ¼ in., 9c.; ⅜ in., 12c.; 1 in., 17½c.; 2 in., 37½c.; 2½ in., 59c.; 3 in., 77c.; 4 in., $1.10; 6 in., $1.94. 1 to 3 in., Butt Weld Black	Galv.	2½ to 6 in., Lap Weld Black	Galv.
Atlanta	$40.00	$0.225	$0.405	$1.4625	$3.25	$80.00	$128.00	$0.625	$1.625	52%	44.5%	50%	42%
Baltimore	43.50	.32	.55	2.50	4.75	85.00	150.00	.60	1.75	....	....	....	....
Birmingham	36.00	.30	.54	1.95	5.00	....	....	....	....	....	....	....	....
Boston	45.50	.29	.56	2.91	7.45	60.10	101.00	.45	2.00	55.59%	44.83%	56.85%	46.10%
Chicago	44.00	.35	.675	2.25	5.125	120.00	200.00	.675	2.25	....	....	....	....
Cincinnati	43.00	.224	.432	1.71	5.2275	90.00	....	.38	1.30	57.33%	46.31%	58.55%	47.53%
Cleveland	44.50	.203	.3915	1.755	5.6375	42.50	88.50	.536	2.102	59.4%	48.4%	60.6%	49.6%
Dallas	48.00	.3325	.465	....	....	99.00	....	.60	2.27	....	....	....	....
Denver	56.00	.23‡	.415‡	1.73‡	....	100.50‡	....	....	....	....	....	....	....
Detroit	44.50	.28	.54	2.25	....	100.00	150.00	....	....	....	....	....	....
Kansas City	46.00	.33	.52	1.90	3.80	120.00	180.00	....	....	....	....	....	....
Los Angeles	44.50	.2825‡	.508‡	2.03‡	5.535‡	115.50	192.50	1.00	2.00	....	....	....	....
Minneapolis	46.50	.215‡	.387‡	1.548‡	4.35‡	64.90	120.00	....	....	53%	42%	54%	43%
Montreal	....	....	1.02	3.64	....	....	....	....	....	....	....	....	....
New Orleans	42.00	.28	.392	1.90	....	45.00	....	.45	1.65	....	....	....	....
New York	43.00	.35	.675	2.83	7.48	....	....	.55	2.00	56.164%	45.144%	57.389%†	46.368%†
Philadelphia	41.50	.23	.54	1.80	....	135.00	210.00	....	....	56.65%	45.63%	57.88%	46.86%
Pittsburgh	46.00	.175‡	.3375‡	1.53‡	4.8175‡	46.00	82.00	.75	1.75	67.5%	58.5%	68.5%†	59.5%†
St. Louis	43.00	.27	.486	1.944	3.96	85.00	195.00	.45	1.55	55.796%	44.76%	57.021%	46.0%
San Francisco	44.00	.25	.45	1.80	4.50	112.00	170.00	....	....	60.1%	52.4%	62.4%	53.1%
Seattle	45.50	.35	.63	2.52	....	84.00	200.00	.50	1.60	60.3%	51.3%	63.3%	52.3%
Burlington, N. J. (base)	40.00	....	....	....	....	....	....	....	....	....	....	....	....

*Gas pipe and class A, $3 per ton additional, 4-in., $3 per ton additional. †3½ to 6 in. ‡f.o.b.

Lumber and Timber

		SHORT LEAF YELLOW PINE AND DOUGLAS FIR Per M ft. b.m., carload lots f.o.b. All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. All Fir planks No. 2 common; Fir timber is No. 1 common. S. L. Y. P. lumber is 10 to 20 ft. Fir lumber is up to 20 ft. 1x6, S4S	1x8, S4S	2x4, S4S	2x6, S4S	2x8, S4S	2x10 S4S	3x12 Rgh	6x12 Rgh.	12x12, Rgh.	LONG LEAF Y. P. Per M ft. b.m., carload lots, f.o.b., merchantable grade up to 20 ft. 2x12, Rgh.	12x12, Rgh.
Atlanta	Southern Pine	$20.00	$21.00	$23.00	$20.00	$21.50	$22.00	$30.00	.....	.....	40.00	$45.00
Baltimore	Southern Pine	26.00	27.50	30.00	28.00	29.00	31.00	40.00	.....	.....	60.00	58.00
	Douglas Fir	29.50	29.50	32.50	31.50	32.00	33.00	33.50	$32.50	$32.50	.....	.....
Birmingham	Southern Pine	40.00	40.00	.....	.....	.....	.....	50.00	.....	55.00	.....	.....
Boston	Southern Pine	32.00	32.00	38.00†	38.00†	62.00‡	67.00‡	70.00‡	.....	.....	72.00	72.00
	Douglas Fir	31.00	31.00	35.00	35.00	37.00	39.00	42.00	42.00	42.00	.....	.....
Chicago	Southern Pine	34.00	35.00	33.00	32.	33.00	34.00	49.00	65.00	65.00	54.00	54.00
	Douglas Fir	40.00	42.00	40.00	40.00	40.00	42.00	50.00	50.00	50.00	.....	.....
Cincinnati	Southern Pine	32.00	32.00	32.00	31.00	31.00	34.00	40.00	.....	.....	.....	.....
	Douglas Fir	.....	.....	.....	.....	.....	.....	47.50	47.50	50.00	.....	.....
Cleveland	Southern Pine	30.50	31.50	37.50	35.50	36.50	38.00	46.75	.....	.....	36.75	56.75
	Douglas Fir	.....	.....	36.75	.....	.....	.....	.....	44.25	.....	.....	.....
Dallas	Southern Pine	30.00	31.00	32.50	28.60	31.25	32.75	42.50	.....	.....	45.25	40.70
	Douglas Fir	.....	.....	35.00	33.25	33.25	33.50	41.50	46.00	46.00	.....	.....
Denver	Douglas Fir	40.00*	40.00*	40.00*	40.00*	40.00*	41.00*	51.00*	58.00*	.....	.....	.....
Detroit	Southern Pine	29.00	30.00	32.00	29.00	31.00	32.00	36.00	.....	.....	34.00	47.00
	Douglas Fir	.....	.....	.....	.....	.....	.....	44.00	45.00	47.00	.....	.....
Los Angeles	Douglas Fir	27.00	27.00	27.00	27.00	27.00	30.00	27.00	31.00	28.00	.....	.....
Minneapolis	Western Pine	47.00	47.00	41.00	41.00	41.00	39.00	47.50	.....	.....	.....	.....
	Douglas Fir	34.50	34.50	34.50	34.50	34.50	39.00	44.50	44.50	42.50	49.50	49.50
Montreal	Spruce	27.00	29.00	21.00	23.00	24.50	31.50	34.50	.....	.....	.....	.....
	Douglas Fir	48.00	51.00	45.00	50.00	53.00	62.00	.....	.....	.....	.....	.....
New Orleans	Southern Pine	18.00	19.00	.....	.....	.....	.....	30.00	.....	.....	.....	.....
	Douglas Fir	21.00	21.00	.....	.....	.....	.....	42.50	.....	.....	.....	.....
New York	Southern Pine	33.00	34.00	35.00	35.00	35.00	37.00	36.00	.....	.....	75.00	75.00
	Douglas Fir	.....	.....	38.00	36.00	37.00	37.00	36.00	40.00	40.00	.....	.....
Philadelphia	Southern Pine	29.00	30.00	28.50	28.00	29.00	31.00	34.00	.....	.....	64.00	64.00
	Douglas Fir	.....	.....	34.50	34.50	35.00	35.00	37.50	40.00	40.00	.....	.....
Pittsburgh	Southern Pine	26.50	27.75	32.75	29.25	31.75	32.75	41.50	.....	.....	57.50	57.50
	Douglas Fir	33.50	34.50	34.50	33.50	34.00	34.25	46.25	46.25	46.25	.....	.....
St. Louis	Southern Pine	33.00*	35.00*	33.00*	31.00*	32.50*	41.00*	49.00*	.....	.....	59.00*	61.00*
	Douglas Fir	.....	.....	.....	.....	.....	.....	59.00*	59.00*	59.00*	.....	.....
San Francisco	Douglas Fir	28.00	28.00	28.00	28.00	28.00	30.00	29.00	31.00	31.00	.....	.....
Seattle	Douglas Fir	22.50	21.50	21.50	21.00	22.00	22.50	20.00	20.00	22.00	.....	.....

*Delivered. †Spruce. ‡Long-leafed Y. P.

Current Building and Construction Wage Rates Per Hour

	Bricklayers	Carpenters	Structural Iron Workers	Hoisting Engineers	Plasterers	Common Labor Building	Common Labor Heavy Const
Atlanta	$0.75/1.125	$0.40/.90	$0.60/1.25	$0.60/1.25	$0.50/.75	$0.30/.40	$0.30/.40
Baltimore	1.10	1.10	1.10	1.10	1.10	.45	.45
Birmingham	.75/.87½	.60	.75	.75	.....	.25/.30	.25/.30
Boston	.90/1.30	.70/1.17½	1.20	.90/1.17½	.90/1.62½	.40/.70	.40/.70
Cincinnati	1.27½	1.02½	1.20	1.07½	1.27½	.45	.40
Chicago	1.50	1.31¼	1.35	1.31¼	1.50	.82½	.82½
Cleveland	1.25	1.12½	1.25	1.125	1.25	.72	.72
Dallas	1.12½	1.00	1.00	1.00	1.25	.40	.40
Denver	.60/1.12½	.60/.87½	.60/.87½	.60/.87½	.....	.50	.50
Detroit	1.00/1.10	.75/1.25	1.00	.70/.90	1.25	.50	.50
Kansas City	1.32½	1.12½	1.12½	1.12½	1.32½	.60/.70	.62½
Los Angeles	.90	.75	1.12½	.75	1.00	.50	.60
Minneapolis	.90/1.00	.75	.90	.75	.90	.40	.50
New Orleans	1.00	.75	1.00	1.00	1.25	.30/.40	.30/.40
New York	1.50/1.65	1.25/1.40	1.65	1.50/1.65	1.50	.93¾	.62½/.82½
Philadelphia	.75/1.50	.50/1.00	1.00/1.37½	.75/1.67	75/1.37½	.30/.40	.30/.40
Pittsburgh	.50/1.00	.50/1.00	.50/1.00	.50/1.00	.50/1.00	.35/.50	.35/.50
St. Louis	1.50	1.25	1.47	1.35/1.47	1.50	.78¾	.35/.78¾
San Francisco	1.12½	.90	1.20	1.00	1.10	.60	.60
Seattle	1.20	.90	1.10	1.00	1.20	.60	.60
Montreal	1.20	.55	.85	.85	.85	.30	.20

Skilled Ave: (Bricklayers, Carp., Ironworkers) $1.054. Common Ave. $0.5158